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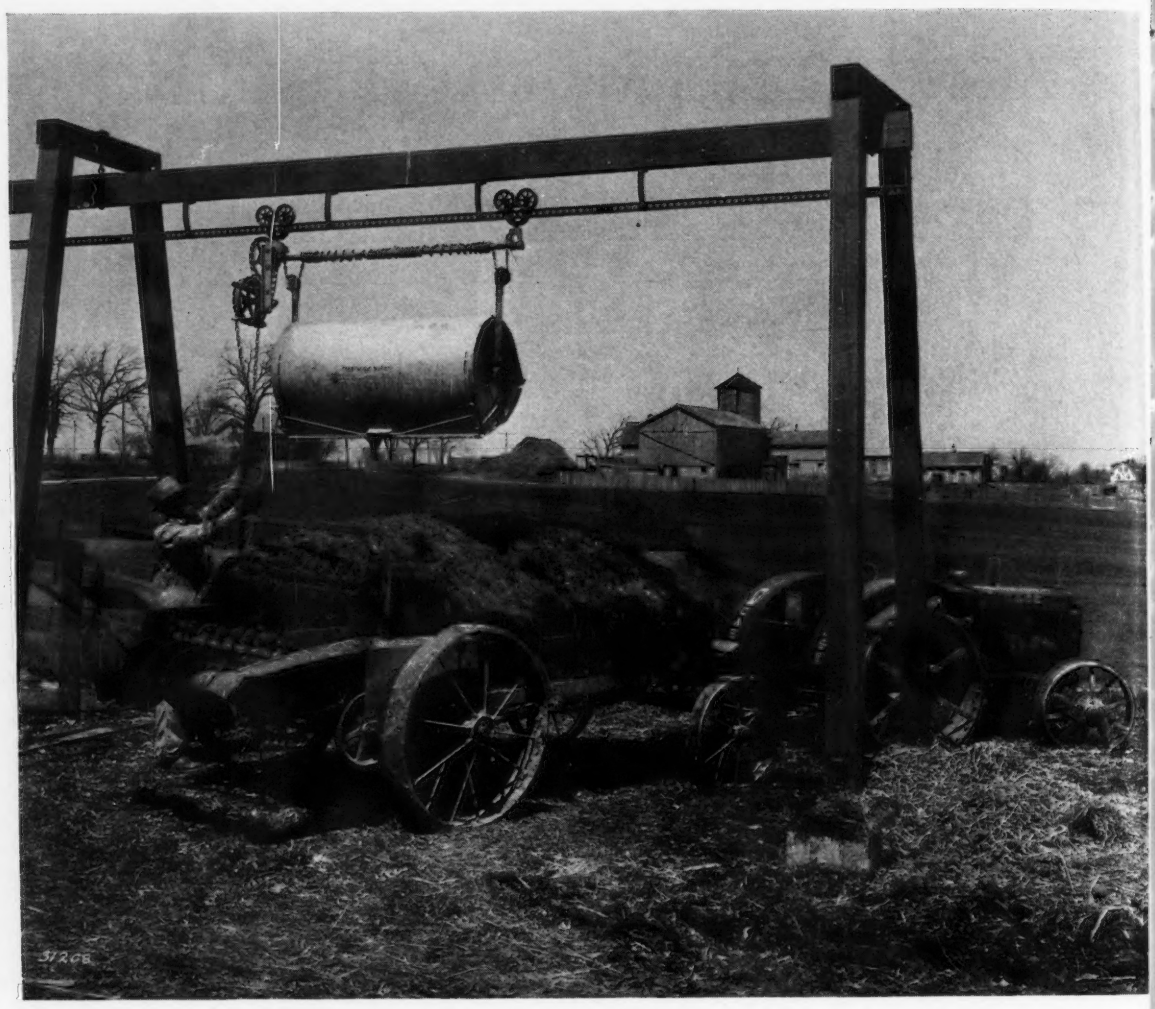

Materials Handling on the Modern Farm

THE FINE engineering which has developed and provided modern farm equipment, achieves its destiny of economic and social usefulness when this equipment is fitted into its logical place in an efficient farm-operating plan, and used to increase or improve the farmer's service of production. Lower cost of food to consumers, conservation of farm productive capacity, and conservation of time, energy, and funds for better farm living are made possible. Most farmers handle a heavy tonnage of a wide variety of materials. The development of specialized handling equipment, and of principles governing its contribution to overall farm-production efficiency, is an agricultural engineering job.

AGRICULTURAL ENGINEERING

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The Bottleneck in Rural Electrification

AN APPEAL to the public agencies of agriculture to view rural electrification as a matter of farm building, rather than a matter of line and load building, has been sounded by George W. Kable, editor of "Electricity-on-the-Farm."

Specifically, Mr. Kable's contention is that the public acts under which the Rural Electrification Administration operates overemphasize line building, and use public funds to benefit a comparatively small number of farmers, at the expense of possible rural electrification research and extension work which could promote rural electrification on a more sound basis with benefit to a much larger number of farmers. He also maintains that the U. S. Department of Agriculture. which has facilities for the administration and conduct of research and extension work, should logically have the responsibility and administration of funds provided for this work because the major problem therein is agricultural.

Without presuming authority on the public policy problem as to what should be done about it, we are inclined to agree with Mr. Kable that, technically, rural electrification is largely an agricultural problem. It is the problem of using electricity as a tool to improve farm living and the farmers' economic service of production. When the majority of those farmers who already have electric service available can be shown the methods and economy of utilizing it fully, and when it has become part and parcel of their life and work, rather than an appendage, kilowatt-hour consumption will be greatly increased, and lower equipment costs, lower rates, and more lines can be justified, and more individual units will come into use beyond the reach of power lines.

Just enough farmers are making extensive profitable use of electricity to show that the majority of others having current, and having been subjected to the same load-building salesmanship, still lack some information, understanding, or incentive necessary to place them in the same farming class. They need the help which research and genuine educational effort can give to start them using electricity profitably, not only as an improvement on the kerosene lamp, but in all of their operations where light, power, heat, or other effects of electricity might be used to save labor, reduce waste, improve the product, reduce hazards, improve working conditions, or otherwise increase their capacity to produce salable goods or services.

Many possible applications have proven practical under certain circumstances. The limits of their practicability need to be defined and made general farm knowledge. Additional applications should be developed to meet agricultural needs. Agricultural and business principles of the farm use of electricity need to be worked out and clearly worded. Rural electrification crosses all branches of agricultural science, and finds usefulness in most types of farming and farm operations.

The bottleneck in rural electrification is not in any lack of technical mastery of electrical phenomena. It is not any industrial reluctance to provide the means of generating or distributing current to any point where the economy of its use will justify the cost. It is in engineering its applications to a unique biological enterprise, in introducing it as a complex, versatile new tool, to a conservative element of the population, requiring a considerable initial investment on their part and adjustment to new ways of working and living.

Yes, the bottleneck is in agriculture. If the natural course of progress in rural electrification is to be accelerated, it would seem desirable that this be recognized and the major accelerating effort and support applied toward engineering electric power into an integral place in farm life and work.

Vegetable Packaging

VEGETABLE growers have an engineering problem in providing the best and most economical physical containers to carry their biological products through unfavorable physical environments, with a minimum of physical and chemical deterioration, for ultimate biological consumption. The possible combinations of product characteristics, environmental conditions, human factors, and physical agencies of packaging are almost infinite; the workable improvements hard to find.

Paul Work of the vegetable crops department of Cornell University, in an article in the December 1937 issue of "Modern Packaging," points out trends toward meeting two distinct classes of market demand. One is fancy dress for fancy goods, for fancy trade, at presumably fancy prices. The other, and more important from the standpoint of volume, is attractive, serviceable, low-cost packaging that meets sanitary requirements and helps preserve good standard grades of products until they reach the average consumer.

From the standpoint of physical means of meeting biological requirements in a farm or farm community production operation, the packaging of vegetables, fruit, and other perishables is distinctly a problem in which agricultural engineers can and should be of service. It is another case in which physical requirements from the standpoints of the biological product and the consumer might be defined by appropriate specialists, and engineering problems of meeting those requirements worked out by agricultural engineers. We submit that optimum conditions and permissable limits as to temperature, humidity, air movement, air content, dust concentration, decomposition, chemical preservatives, cleaning agents, protective coatings, physical properties of packaging materials, agencies and means of performing operations, controls, and unit costs are engineering language and matters in which agricultural engineers might well contribute to the farm-operating-efficiency phase of vegetable marketing. A limited amount of agricultural engineering work along these lines has already been done. Organized cooperation and defined biological and market requirements might provide the incentive and support necessary to increased work in this field.

Tenant Farms

FARMS left by mortgage default as foundlings on the doorsteps of mortgage holders who neither want farms nor are qualified to manage them, have become problem children of agriculture to an extent indicated by G. B. Hanson in his paper published elsewhere in this issue.

As a basis for improvement of the situation, it would seem desirable that certain considerations be brought to the attention of both the owners and the tenants of the problem farms. It occurs to us that some of these considerations are as follows:

Investment over and above the current appraised valuations of comparable farm land and buildings in the community might well be written off as a loss. Decision to sell, operate, or improve can intelligently be based only on present and probable future values. There seems to be little hope of a general, near-future rise in land values to warrant a policy of neglectful waiting. Land values seem due to become an increasingly accurate capitalization of capacity to yield a net return at low unit prices on products, by high productivity at low unit cost. Neither do present prices of farm products offer the prospect of a profit on former paper values by operations to mine farms of their productive capacity by careless cropping and failure of maintenance. Operations planned to take from a farm what it will produce, without maintenance of land and buildings, are analogous to the bad financial practice of paying dividends out of capital.

Improved methods, materials, and equipment, with balanced investment and good operating management, are making many farms profitable under present conditions. It seems probable that any of the present problem tenant farms which are not inherently submarginal, could likewise be made to pay a reasonable profit on a fair valuation. In fact, this appears to offer the best prospect for the greatest return to the owner, whether he wishes to sell when the opportunity arises or to maintain his equity, and to the tenant, whether he wishes to remain a tenant or to ultimately buy a farm of his own.

It is possible for an understanding owner and a good tenant to arrive at an operating agreement which gives each a desirable incentive to maintain the investment, while using the farm to its capacity as a productive enterprise in the interest of both.

These considerations seem to leave the owner two reasonable alternatives. He can resell immediately for what he can get, and take his loss. Or, if in a position to do so, he may take his farm ownership seriously and look forward to a smaller loss, or even a profit on a fair valuation, by holding the property for a time and managing it wisely. Holding, without wise management, including careful operation and maintenance, offers little prospect of increasing the salvage value of the investment. The surveyed boundaries of the property, the recorded deed, and the insurance on buildings are not enough to hold its agricultural value intact. The problem farm needs a new owner, a new tenant, or a new owner-tenant agreement to encourage good farming and maintenance of low-cost productive capacity.

Meeting Commentary

ATTENDANCE at the fall meeting of the American Society of Agricultural Engineers set a new record of 411 registrations. Of these 224 were ASAE members, showing the Society represented by more than 21 per cent of its total membership.

Nonmembers attending, whose interest indicates that they might be logical candidates, totalled 161, closely paralleling the nonmember attendance at the last annual meeting. Of these, seven were former members with a continuing interest in the Society indicated by their presence. The names of 17 others attending had recently been submitted by members as logical candidates for membership. And 137 were close enough to agricultural engineering and agricultural engineers to know about the meeting; interested enough in the program to attend; but not identified to the ASAE executive office by any member as being currently interested enough to warrant consideration as prospective members.

If the meeting drew the same percentage of prospective members as it did of members, there must be at least some 600 logical but unreported and unsolicited prospects for ASAE membership in and about North America. A continued healthy growth of the Society seems to be within its reach.

Farm Production Engineering

PROGRESS in many individual features of agricultural engineering is noted in the recently published annual report of the chief of the U. S. Bureau of Agricultural Engineering. The most striking revelations, to us, are those dealing with the farm-operating efficiency investigations—the integration of improved methods, materials, and equipment into more efficient farm-operating units.

If we interpret the report correctly, it shows that improvement of individual farm crops, practices, and pieces of equipment, however meritorious, needs to be supplemented by fitting them into existing farm production setups. While complicated schemes are being concocted to increase the farm income, a large-scale opportunity to show farmers how to pick up extra dollars easily within their reach is being neglected.

Assembly-line methods of production may not be applicable to farm operations as a whole, but the Bureau study is far enough along to support the common sense appeal of a balanced production program and production facilities. The objective of the investigation is excellent. The cooperation secured from other branches of agricultural science is commendable.

In the past, farm acceptance of various available improvements has been slowed down because they have been misapplied, or some other related but unstudied factor in the farm operations has prevented their full utilization and success. When extension agricultural engineers can take to farmers principles of high overall production efficiency and help them to see and overcome whatever may be the limiting factors in their individual production programs, we may expect farmers to show increased confidence in and support for all agricultural engineering work.

Farm Experience with Wind Electric Plants

By Fred W. Hawthorn

HIGH-LINE service is recommended wherever it can economically be made available. Wind electric plants are in no sense to be considered competitive, for their field logically commences where the high lines end.

The idea of getting power from the wind dates back at least to the first sailing vessel. For close to a century, wind power has been extensively used to pump the farmstead water supply. However, its application to the generation of electricity is quite recent. About twenty years ago, some electrically minded farm boys started experimenting with wind-mill wheels belted up to discarded light plant generators. A little later they discovered that a two-blade propeller, whittled out of a plank to a special airfoil cross-section, would produce far more power and speed. The modern, direct-drive wind plant is an evolution of this type of propeller coupled to a low-speed generator. From this humble beginning out on our western ranches has come a new, rapidly growing industry that promises an answer to our problem of electricity for millions of isolated farm homes. So much for the historical background.

Three years ago I was confronted with a rural electrification problem on my western Iowa farm, having a new home and no electric service. High-line service was definitely out, for only one customer per mile of line could be secured. After considerable investigation, a modern wind electric plant was installed.

In 1926, J. B. Davidson and E. G. McKibben made a year's test on a 1000-watt wind plant at Iowa State College. Their bulletin, No. 297, describing this test, was considered the most outstanding and comprehensive treatise on the subject. Feeling the need for information on a more modern plant, we secured the loan of special watthour meters from the agricultural engineering department of Iowa State College and for two and one-half years we have been running tests under typical farm loads.

I will give first a brief description of the plant. The 400-lb generator, rated at 1500 watts, is powered with a 14-ft, three-blade propeller directly coupled to the armature shaft, which turns on sealed-in-grease type ball bearings. A flyball governor varies the pitch of the propeller blades, holding the speed below 220 rpm regardless of load or wind velocity.

Both charging rate and voltage are automatically controlled by a device that adds resistance to the generator field circuit when the line voltage reaches 41 volts. This reduces charging to a trickle rate during the finishing period, which prolongs battery life and prevents overcharging. This same device also protects appliances from excessively high voltage, makes generator burnouts next to impossible and reduces operator attention to a minimum. The lead type batteries are rated at 405 amp-hr and are capable of storing about 12 kwh of electric enerby. While 32 volts is the standard for wind plants, 110-volt generators are available for locations where current must be carried a considerable distance.

Our load first consisted of 44 lamps, ranging from 25 to 100 watts, for lighting the house and barn, a 300-watt flood light, electric washing machine, iron, vacuum sweeper, fan, heating pad, corn popper, toaster, hot plate, and two ½-hp motors, one for powering the pressure water system and the other for operating the tool and sickle grinder. A little later an all-electric radio was added and, for the past year and a half, we have operated a 5-ft refrigerator from the plant. An electric brooder was used during May of this year.

Two 50-watt, 32-volt watthour meters were used for measuring current put into and taken from batteries. When checked against the current used by mazda bulbs in loads ranging for 25 to 1200 watts, the meter readings were consistently low and had to be corrected by dividing by 0.74. A recent check on these meters by the electrical engineering department of Iowa State College found this factor to be 0.85, which gives output readings considerably lower than the former factor. The Iowa State College correction figure is used throughout this paper.

The ratio of input to output averaged 83 per cent, this high efficiency being explained by the fact that a large part of the current is used directly from the generator, with the batteries merely floating on the line. For the 30-month period from May 1935 to November of this year, the corrected input meter reading totaled 1586 Kwh an average of 52.9 Kwh per month. At present the monthly input is around 70 Kwh.

It was found impractical to run maximum output tests for the entire 30-month period; but for the month of October maximum output was obtained by plugging in hot plates and flat irons to use up the excess current generated. The total current actually taken from the batteries was 153 Kwh for the month. October is a month of normal wind movements, so this result may be considered as about average.

We find a rather close relationship between our daily output and wind movements of a nearby station. From this data we estimate a maximum output ranging from 300 Kwh for the windy months of March or April down to 105 Kwh for August, the month of lowest wind velocities. It is during this month that wind plants get their most severe test, as this is also the time when refrigeration and water pumping loads are about maximum. Last August

Presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1, 1937.

Author: Farmer, experimenter, and writer, Castana, Iowa. Mem. ASAE.

THE WIND ELECTRIC PLANT ON THE AUTHOR'S FARM

we generated 68.7 Kwh with the plant shut off a considerable part of the time.

The 1000-watt plant tested at Iowa State College in 1926 was only able to generate around 15 Kwh during August. This plant started generating in winds of 10 mph as compared to a cut-in speed of 7 mph for our plant. It reached its top rate of 20 amps at 26 mph as compared to 40 amp at 18 mph for our plant. Winds of high velocity occur for comparatively few hours per month, so the great share of our current must be generated in the prevailing breezes ranging from 7 to 15 mph. It is particularly in these low winds that modern plants, with far more efficient generators and propellers, greatly outperform the models of a decade ago.

Wind velocities vary greatly in different parts of the United States. Generally speaking, the east and west mountainous regions and parts of states bordering the Gulf of Mexico have wind velocities too low for the practical use of wind plants. Wind velocities are above average in the great farming area between the Appalachian and Rocky Mountain ranges.

The maximum load that can be operated from our plant is about 1500 watts from the batteries and 3000 watts when the wind is blowing over 18 mph, the higher figure being the combined output of plant and batteries. While this load limitation might be a serious objection in some cases. we have not found it so on our farm. Since our heavy belt jobs are scattered over the farm, the portability of our general-purpose tractor makes it the ideal power unit for this work. The lighter belt jobs can be handled by motors of such sizes as can be operated from the wind plant.

I will not discuss the 6-volt wind chargers, designed to take care of the farm radio battery, except to state that one company is putting out thousands of these units per week and they seem to be giving satisfaction. There are now eight leading manufacturers in the 32-volt wind electric field. The smallest plant on the market is a 650-watt job that retails for around $85, or, with mast type tower and average size battery, complete for around $250. We put a watthour meter on a plant of this type, and from October 1936 to October 1937 the output totaled 275 Kwh, an average of 22.9 Kwh per month. This was for ordinary farm use with no attempt to get maximum output. Such a plant could be expected to take care of the ordinary requirements for lights, washing machine, radio, and other light-duty service.

From this small plant, the farmer has a choice of either geared or direct-drive plants ranging on up to 5000-watt size. Direct-drive plants, with their heavier generators, are considerably higher in price for the same output but should last much longer than the high speed, geared jobs. Some 600 and 700 amp-hr batteries have recently been developed for use in the large size wind plants. A complete installation of this type would cost around $1000, but would have at least double the output of our plant and should take care of the load on most all larger farms and ranches.

There seems to be a general opinion that the larger the battery, the better for wind electric service. We now know that it is very important to choose a size of battery that will match the plant. If too large a battery is used, the resulting low charging rate will cause sulfation of the plates; if the battery is too small, it will be charged too fast and its life shortened. Personally I recommend the purchase of both large size plant and batteries, as such an installation will carry the load through calms, deliver a far superior, heavy-duty type of service, and will take care of the increased load that will surely come as more gadgets are added.

The investment in tower should be regarded as the purchase of a permanent fuel supply. It is poor economy to try to save a few dollars by skimping on tower height and seriously impair the efficiency of an expensive wind plant.

Even more than with high lines, the cost of wind-generated electricity per kilowatt-hour is determined by the amount used. The power source is absolutely free, and overhead costs are about the same whether you use one or one hundred kilowatt-hour per month. The REA often uses 100 Kwh per month as a basis of computing costs. Since this is within the capacity of our plant, let us use the same figure.

Our windmill is over 30 yr old and in good condition. Due to better bearings and construction, I believe the wind plant will outlast the windmill, but I am going to estimate its life at 25 yr and the galvanized tower at 40 yr. The average life of a 160-amp-hr light plant battery has been found to be 6 yr. Battery men estimate the big 405-amp-hr size will last from 8 to 12 yr. Let us be conservative and use the lower figure.

We have not spent a cent on repairs, but a report on 30 Kansas plants shows an average annual repair and oil bill of $1.56. An investigation of 66 Iowa plants by McKibben and Davidson found the annual repair bill to be $1.99. Averaging the two results gives $1.75. The table appearing below gives the cost data on our plant computed on the basis just outlined and with interest at 4 per cent. Our cost per kilowatt-hour has been much higher than that given in the table because, until lately, we have lacked a lot of using 100 Kwh per month.

Cost Estimates on a 1500 Watt Wind Electric Plant

Depreciation on plant (4 per cent of $495)	$19.80
Depreciation on batteries (12½ per cent of $205)	25.62
Depreciation on tower (2½ per cent of $110)	2.75
Interest on investment (4 per cent of ½ of $810)	16.20
Annual oil and repair bill	1.75
Total annual costs	$66.15
Cost per month	$ 5.50
Cost per kwh (Basis of 100 Kwh per month)	.055

Wind plant designers have met the problem of designing a propeller that will produce power from the light breezes, yet governed so that it will not damage itself or burn out a generator when operating in a hurricane. Cheaper storage is still a major problem, for electricity generated in today's wind must be stored for use in tomorrow's calm. Any developments tending toward lower cost storage of electric energy will greatly affect the wind plant picture.

The outstanding advantage of wind generated electricity is that its cost is absolutely independent of the customer-per-mile factor. Extreme isolation means nothing to a wind plant owner. Admiral Byrd, from a plant like ours at Little America, received the same low cost service that we have enjoyed. Obviously the logical field of the wind plant is in the midwestern and Great Plains states where wind velocities are above normal and where a large share of the farmsteads are so far apart as to make the cost of building and maintaining high lines excessive.

Can a farmer depend on wind generated electricity? Based on our three years of practical experience, the answer would have to be an emphatic Yes. Using all of our equipment as freely as desired, we have never once been without sufficient current since our plant was installed. A record of uninterrupted service for a three-year period leads me to recommend a wind plant installation for any farm home beyond the reach of a high line, where wind velocities are satisfactory, and where the electric requirements are within the limits we have outlined for this type of service.

Low Cost Building Construction in Practice

By K. J. T. Ekblaw

USE OF simple, commonly available, and easily applied materials characterizes the construction of the small home described in this paper. This type of construction was originally developed by the Combined Metals Reduction Company of Stockton, Utah, for use in homes of operatives. It has proved successful, and there appears to be no particular reason why it should not be just as successful when used in farm homes.

Weather conditions in the vicinity of the plant at which this type of construction was used are quite severe. The temperature reaches 100 F (degrees fahrenheit) in summer, and drops under 30 F below zero in winter. Strong winds prevail. In order to provide comfort for the operatives, the homes had to be insulated against heat as well as cold, and the walls had to be fairly tight. Fire resistance was a serious consideration. Economy in first cost and in maintenance was essential.

The chief engineer of the company, W. H. Kelsey, finally developed a method of construction which has been followed in a number of buildings, not only residences, but in offices, stores, and other buildings of moderate size, in which the operatives had to work. The chief departure from the usual type of construction is in the sealing of dead air spaces in the wall between the interior and exterior wall coverings. These coverings may both be galvanized iron sheets or may be sided by plaster board.

A plan of a typical residence is shown in Fig. 1. Of course any such plan may be modified to fit local conditions without changing the method of construction. However, the plan shown might work out well as a convenient farm home.

The distinctive features of the construction appear in Fig. 2, which shows a vertical section through the wall and the lower part of the roof. The foundation wall is of concrete, approximately 8 in thick; the footing may be whatever the type of soil requires. Arrangement of the foundation plate, the floor joists, and the studding is more or less typical. Instead of the use of lath and plaster on the inside walls and ceiling, insulation board ½ in thick is used; heavier insulation can be used if needed. Mineral wool laid to a depth of 2 in covers the ceiling between the joists. The exterior wall covering is of ½-in insulation board, over which is applied galvanized siding; although any of the standard forms of galvanized siding are equally desirable, in this particular case 2½-in corrugated galvanized material was used.

An important detail is sealing the ends of the sheets. This was done by butting the sheet at the top against a stop, and at the bottom by pouring concrete against the sheet. This is a satisfactory way of making the spaces formed by the corrugations of the siding tight. If the wall covering outside and the wall lining inside are made tight so that the air spaces between the studding are sealed, the dead air spaces form effective insulation.

The roof is constructed in the usual way, covering the rafters with solid matched sheathing and 2½-in corrugated, galvanized metal roofing, with building paper between the sheathing and the metal; or what is better and less expensive, ½-in insulation covered with corrugated galvanized iron may be used on the roof.

"Seal of Quality" two-ounce zinc-coated corrugated sheets were used on the sides and roofs of all buildings for the sake of extended durability and freedom from maintenance costs. Special lead-seal roofing nails with screw shanks were used to insure freedom from leakage and to counteract weather action which tends to work straight-shank nails loose.

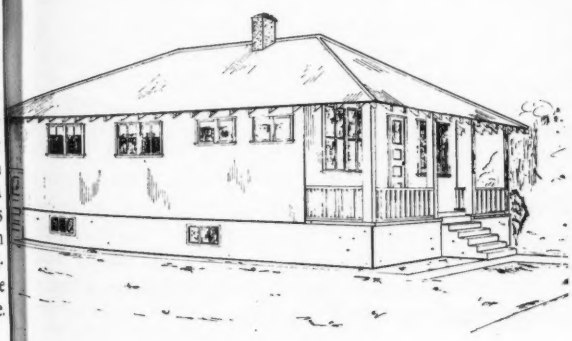
Standard pipes 8 in in diameter constitute the flues for the pipeless furnace and the kitchen range, connections being made by means of welded outlets. A single thickness of brick surrounds the pipes to form the chimney. Such a chimney and flue construction is leak-tight and fireproof, with a smooth interior that helps to provide good draft.

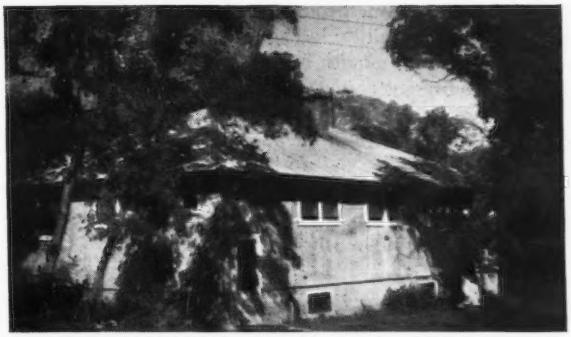
In reporting on the experience of his company with this type of construction, the general manager, E. H. Snyder, mentions several features which have worked out to practical advantage:

"The relentless summer sun in this region frequently gives us daytime temperature ranging above 100 F. Brick, tile, and plaster buildings absorb heat during the day and release it to the discomfort of the residents of the house

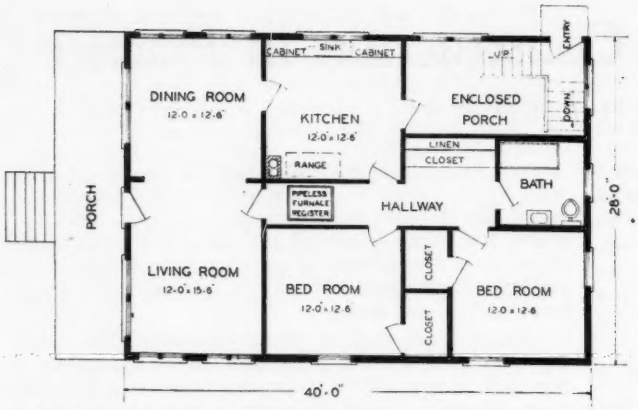
Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Urbana, Illinois, June 24, 1937.

Author: Agricultural engineer, American Zinc Institute. Mem. ASAE.





ONE OF THE LOW-COST, METAL-CLAD HOUSES DESCRIBED BY THE AUTHOR



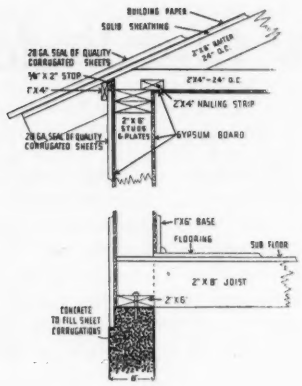


FIG. 1 (LEFT) FLOOR PLAN AND FIG. 2 (RIGHT) SIDE SECTION CONSTRUCTION DETAIL OF GALVANIZED METAL-CLAD HOUSE

far into the night. Galvanized sheets reflect heat, and absorb far less under similar exposures than do tile, brick, and plaster. Our country is noted for its cool summer evenings and nights; homes like the one described here can be cooled rapidly by opening windows and doors after the sun goes down, because there are no massive walls to release stored heat.

"My own office of a similar construction, using galvanized sheets for outside wall and lined with insulation board, is generally 10 F cooler in summer than offices in adjacent brick buildings. On the other hand, I was able to heat my office with a small electric heater on winter days when the thermometer registered more than 25 F below zero.

"The cost of buildings in which this type of construction was used was approximately 50 per cent of the cost of brick houses of the same size and arrangement; a minimum of high-priced labor was necessary. Even frame or wood buildings, which are not suited to our climate, would have cost as much or more.

"We expect to have practically no maintenance expense on the galvanized sheet walls and roof because the heavy zinc coating will require no painting and type of nails used will keep the sheets in place for the life of the building."

An English View of American Agricultural Engineering

THE OBJECT of my visit to the United States and Canada is, broadly speaking, to study the scope, methods, and achievements of agricultural engineers.

The research, advisory, and educational services in agricultural engineering are more highly organized in the United States than anywhere else in the World. I have been very favorably impressed by these services, and have noted many points which I think should be copied in England.

In connection with research, it is interesting to observe the development of certain types of study which do not and can not for many years produce results capable of practical exploitation. During the last twenty years of hectic advances in the mechanization of farming, there have been many opportunities for agricultural engineers to do work which produces quick results, and good use has been made of these opportunities. But it is now being gradually realized that agricultural engineering can involve problems similar to some of those in the pure and biological sciences, in which the results of the work can not be at once translated into dollars or pounds.

In the field of education in agricultural engineering, we in England have much to learn from America, for little serious thought has been given in my country to either the scope of the subject or the best methods of teaching it. There is a growing appreciation of the necessity of teaching how the whole problem of engineering in agriculture should be analyzed into fundamental things, and of teaching those fundamentals rather than the details of the construction and use of machinery. Thus a fundamental training in mechanisms facilitates the understanding of the mechanism of any machine, and a training in the fundamentals of the organization of farm power and machinery enables the student to employ these resources to produce crops in the most economical manner.

In your extension service, one of the most striking features, to me, is the work in connection with the improvement of farm homes, both with respect to buildings and equipment. I had not fully realized what an important part of agriculture the farm home can be, until I came to America and saw this work in progress. English agricultural engineers will be doing a service to agriculture and the nation if they can help to bring about similar improvements in the buildings and home equipment of our farmers.

Anyone who has studied the position of agricultural engineering in various countries must realize that we in Europe are continually looking to America for news of recent advances and the best I can say of this is that American advances in agricultural engineering have had a profound effect on British Agriculture.

Abstracted from a paper on "What English and American Agricultural Engineers Can Learn from Each Other," by Claude Culpin, lecturer in agricultural engineering in the School of Agriculture, University of Cambridge, England, presented before the North Atlantic Section of the ASAE at Toronto, Canada, October 12, 1937.

New Mechanical Technique to Develop Vegetative Cover

By F. E. Hardisty, G. F. Delong, and R. L. Dolvin

NEW MECHANICAL methods for quick development of vegetative cover that have been on trial by the Soil Conservation Service at its Athens, Georgia, demonstration project are expected to prove valuable to farmers of the Southeastern states wherever they are organized for community effort in the use of heavy farm machinery.

The application of these methods on the Athens project has improved the technique of establishing meadow strips, of converting existing gullies and abandoned road rights-of-way to vegetative terrace outlets, in constructing vegetative terrace outlets on steep grades, and in developing pasture cover on badly eroded and gullied land. They consist chiefly of a combination of subsoiling to a depth of approximately 18 in, mechanical sowing of grass sprigs or propagation of cover from seed, and mechanical mulching by means of a manure spreader. The erosion-control effects of subsoiling, though temporary, stimulate development of vegetative cover while simultaneously providing temporary storage in the soil for runoff water. Thus the subsoil treatment serves two desirable functions until the vegetative cover has developed sufficiently to carry the burden of erosion control.

The experiments at Athens, though not conclusive in all respects, indicate that these methods are especially adapted to use by projects, conservation districts, county terracing cooperatives, certain CCC camps, highway departments, and such organizations, which have at their disposal sufficient equipment to perform the operations described in this paper. These new methods are equally effective when practiced with ordinary farm equipment, but are necessarily slower when light equipment is used. The equipment needed to perform any of this work on a construction scale consists of one 40-hp track-type tractor, one wheel-type terracing machine, one 3-tooth subsoiler, one manure spreader, and one heavy tractor disk.

General Meadow-Strip Preparation. The increasing use and effectiveness, on southern farms, of those narrow sloping fields of grassed land known as "meadow strips," that serve not only as broad water channels for terrace outlets during periods of runoff but as the best hay fields on many farms, justifies every improved method for their construction. For the construction of the meadow strip, the chosen location is first smoothed with the tractor and terracing machine and disked. Within practical limits the entire strip is made smooth and regular. Contours are then staked across the full width of the meadow strip at vertical intervals of 4 to 6 ft, depending on the grade, and subsoiled to a depth of about 18 in. Such subsoiled strips are usually about 5 ft wide with three deep furrows when the 3-tooth subsoiler is used. The tractor operator then subsoils between the staked contours, leaving a shoulder of approximately 5 ft in width undisturbed between each approximate contour subsoiled. These intermediate subsoiled contours are placed in the same manner as plow furrows between terraces, being approximately on contour and pointed out midway between the staked contours. This treatment provides a total subsoiled area in the meadow strip of from one-third to one-half the total meadow strip area. The methods used from this point on depend on the season of the year in which the work is done and the type of vegetative cover chosen for the strip.

Lespedeza Meadow Strips. In circumstances where the volume of terrace runoff water to be controlled and the slope of the meadow strip seem to justify the use of a protective cover less rugged than Bermuda grass, some hay or forage crop is chosen. For the purpose of this report we will assume that a combination of sericea and annual lespedeza is selected. The first treatment consists of smoothing, disking, and contour subsoiling just as in the preparation for meadow strips. At this point complete commercial fertilizer is broadcast at the rate of 400 to 600 lb per acre. The entire meadow strip area is again disked with a heavy disk followed by the combination drag and spike-tooth implement in tandem. This last operation is made to smooth the rough surface left on the strip by subsoiling as well as to prepare a satisfactory seedbed.

Sericea lespedeza is then sown in the center of the meadow strip at the rate of about 50 lb per acre leaving a strip approximately 20 ft wide on each edge. These outer edges are sown to annual lespedeza at the rate of approximately 50 lb per acre. The purpose of edging the sericea center portion with annual lespedeza is both in the interest of economy and to facilitate the return of these strips to cultivation should observation on the performance of the meadow-strip outlet during periods of runoff indicate the original width chosen is greater than necessary. Since definite standards for minimum meadow strip widths have not yet been worked out, it is customary to provide ample width for all such meadow strips constructed and provision is made to reduce that width if not required.

After sowing the seed, shallow cover is given by a spike-tooth harrow or a two-gang soil pulverizer, depending on the condition and moisture content of the soil. When the soil is damp the section harrow seems to provide the better cover while the pulverizer is favored under dry soil conditions.

The lespedeza meadow strip should be sown in the early spring. To protect wet spots, Dallis grass or carpet grass seed may be used instead of lespedeza. If any reasonable doubt exists as to whether such seed will catch sufficiently to provide the required protection, it is customary to seed sudan grass or some of the millets in contour rows to provide temporary summer cover until adequate protection from the permanent crop can be developed. It is noteworthy that in these methods of meadow-strip development subsoiling of all terrace channels entering the meadow-strip, are relied upon to provide protection from runoff while the contemplated vegetative protection is being developed. The quick development of vegetative cover is imperative with this method and sometimes necessitates reseeding or other emergency measures when the first seed-

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ing does not catch or when unfavorable weather retards the rapid development of vegetative cover.

Bermuda Meadow Strips. Should the strip in question carry an appreciable area of terrace drainage on a slope which might require a Bermuda grass cover, the next operation will be to locate the most convenient source of Bermuda grass and to rip up enough sod with the subsoiler plow set to about a 4-in depth. If the sod occurs within a reasonable distance of the meadow strip, it may be hauled directly in the manure spreader, but long hauls or rough roads necessitate truck transport and rehandling of the grass. Sod in almost any proportion of grass tops, roots and soil can be satisfactorily handled by the spreader.

The spreader should not be loaded over two-thirds full and an open space should be left at the rear of the load so that the burden of sod will be carried gradually to the spreading mechanism. Under the least favorable conditions one such load of sod can be expected to sprig about one-fifth acre or a strip about 10 ft wide and 800 ft long. Note that the Bermuda is spread immediately after subsoiling. The Bermuda sprigs applied in this manner have a very uniform distribution not over 8 in apart in any direction and are finally covered by disking or dragging.

Under the conditions obtaining at the Athens project, about 35 per cent survival of the covered sprigs can be expected when sprigged during the late fall, and as high as 80 per cent when sowed in the spring. It is normally the custom to add to each load of Bermuda about 100 lb of complete commercial fertilizer, which the manure spreader distributes uniformly with the Bermuda grass. When planted in the proper season the Bermuda requires not over six weeks in properly chosen meadow strips to catch sufficiently to provide protection on the meadow strip from terrace runoff. For temporary protection at this time it is customary to subsoil the channels of all terraces entering the strips.

During the period in which the Bermuda is beginning to make growth, runoff in the meadow strip from the subsoil terrace channels can be expected only from the most intense rains. Due to the position of the natural draws in which meadow strips are usually located, the soil as a rule is rich enough to assure quick growth by the Bermuda sprigs. Where farmers dislike Bermuda grass adjacent to cultivated fields, such strips are usually edged with a strip of lespedeza planted as outlined below.

Gullies and Abandoned Road Rights-of-way as Vegetative Terrace Outlets. A variation of the Bermuda terrace outlet practice is applicable where deep gullies or abandoned road locations exist in suitable locations for terrace outlets. The practice in these cases is as follows: All terraces entering the proposed outlet are subsoiled in the channel, or if not yet built their construction is delayed until vegetative cover in the outlet is well developed. The gully is first worked down to a flat depression with the terracer. These fills can ordinarily be made at a cost from three to five cents per cubic yard and have been successfully handled in fill cross sections up to 36 sq ft. When working down the banks it is often desirable to alternate use of the subsoiler and terracing blade in breaking down the hard soil. In making the fills settlement should be anticipated to obtain a satisfactory final cross section.

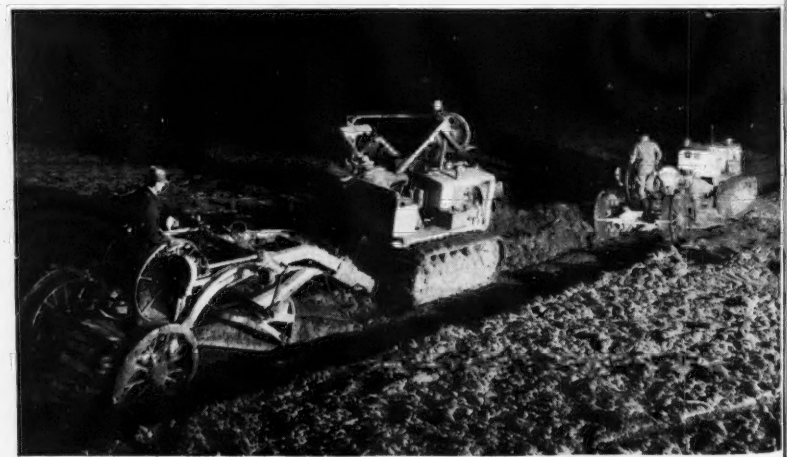
Under normal conditions no subsoiling is done in such outlets because of the depth of fill. After shaping up the cross section, Bermuda grass and commercial fertilizer are applied with the manure spreader. Since this work is done on subsoil after making the required fill it is desirable to sow more Bermuda in this type of outlet than in the ordinary meadow strip described above. On top of the Bermuda sprigs a fine mulch of manure, straw, cane pomace, corn stalks, pine needles, or any other available organic matter is applied with the manure spreader. This mixture of mulch and Bermuda is then covered with the disk. Due to the usual poverty of the soil in such outlets, it is often desirable to add by hand a surface mulch, consisting of pine bough thinnings, straw or brush to help hold moisture on the grass sprigs.

Steep Grade Moderate Velocity Bermuda Terrace Outlets. Successful terrace outlets using Bermuda vegetative protection on slopes up to 15 per cent carrying up to 50 sec-ft of runoff have been constructed at reasonable cost by the following variation of the methods described above.

Where a small natural draw is suitable for a terrace outlet, it is machined to as near a uniform grade as possible with the tractor and terracing machine. A cross section of 20 to 40 ft in width is customary with about one or two feet of depression in the center. Outlets of this type are somewhat narrower than ordinary meadow strips and a distinct subsoiling practice is followed. Instead of subsoiling on the contour, subsoiled furrows are begun at the center of the depression and run on a straight line to the edge of each side of the outlet with a staked fall of 6 in from the center to the edge.

Since such outlets are often in a cut, this subsoiling practice is followed to distribute moisture from the center to the sides of the outlet. After subsoiling, Bermuda sprigs and commercial fertilizer are applied by a manure spreader in the manner described above, but in greater quantities than applied on normal meadow strips where the soil is more productive. Such outlets can be depended on to catch sufficiently to give protection within one month, if planted during a favorable planting season and if protected from terrace runoff by subsoiling all terrace channels entering the outlet.

Pasture Work. Perhaps the most successful application of the mechanical methods for developing vegetative cover has been in connection with *(Continued on page 16)*



Irrigation of Field Crops on the Great Plains

By Leslie Bowen

DURING the past five years the U. S. Department of Agriculture, through its Bureaus of Agricultural Engineering and Plant Industry, at the Scottsbluff Field Station in western Nebraska, has been conducting field experiments on (1) the use of water by field crops under irrigation, and (2) the efficiency of irrigation practices.

This work is being accomplished by accurately measuring all the water applied, both irrigation and rain, to the various crops and by intensive soil sampling for moisture determinations. The plots used are 82.5 ft wide and 132 ft long, each containing an area of 0.25 acre.

In western Nebraska (the North Platte Valley) the climate is typical of the high plains country (altitude 3,500 to 4,200 ft). It is subject to wide extremes of temperature and the low rainfall, 16 in, is variable and comes in light local showers or heavy downpours of short duration. As with other areas on the Great Plains the greater part, about 75 to 80 per cent, of the annual precipitation occurs during the growing season, the months April to September, inclusive. The region is seldom without wind, and evaporation from the soil is so rapid that a light shower has little effect upon vegetation. The last killing frost in the spring usually comes about May 13 and the first killing frost in the fall around September 25, making the length of the frost-free period some 135 days.

The soils have the general characteristics common to regions of light rainfall, being light in color, more or less calcareous, low in organic matter, and friable. There is a wide range of textures. Adjoining the river are the clays, or the heavier soils, while on the rolling and sloping, well-drained uplands, sands and sandy loams are predominant. In general, the soils are fairly productive but, being of the light type, require more or less attention and effort in order that their fertility be maintained. Their maximum water-holding capacity is about 3.4 in for the upper 2 ft of depth; in the upper 4 ft some 8 in can be stored. These values represent all the water between the lower limit, wilting point, and the upper limit field capacity.

Practically all the water used for irrigation is supplied by the North Platte River and its tributaries. The months of April, May, June, and July cover the period of maximum flow of the river. In the upper reaches of the river are two large reservoirs which store part of the flood water for later-season use.

The crops most commonly grown in western Nebraska include wheat, oats, barley, corn, sugar beets, potatoes, beans, alfalfa, sweet clover, and pasture. Such crops as alfalfa, sweet clover, pastures, and small grains are irrigated by flooding, while with row crops such as sugar beets, corn, potatoes, and beans, the furrow method is used. With flood irrigation, while the method of border strip is used on some areas, the greater portion is irrigated by flooding by field ditches, commonly termed "wild flooding." Each of these methods (furrowing and blowing) has merit and during years of adequate water supply each has been successful.

All Growing Crops Require Water. For profitable production there should be ample moisture in the soil from the time of planting until the crop reaches maturity. The total amount of water needed and the time of the year when it is required depends on the kind and amount of crop grown, its stage of growth, the soil, and climatic conditions.

In hot, dry climates, with long seasons of growth, considerably more water is required than is necessary where the climate is more temperate and the growing season shorter.

In areas with an abundance of water there is a tendency on the part of the users to pay little attention to the amount of irrigation water applied. This results in excessive irrigation of many acres. Then too, as a rule, where delivery to the various farms is made by small streams of continuous flow, there is a likelihood of greater water waste, than if delivery on a rotation basis is followed and larger streams are supplied.

Perhaps the greatest single factor influencing the water requirement of the crop is the soil. In theory at least, the water requirement for a crop grown on light sandy soil should be no greater than if it were grown in a heavy clay. However, on sandy soil more water is applied and the waste is larger because of greater soil permeability. The soil acts as a reservoir in which water is stored between irrigations, for the use of the plants. Storage, or waterholding capacity of soils, varies. The capacity per unit volume of coarse-grained soils such as gravels and sands, is not as great as that of the finer-grained, heavier soils, such as the clays and loams, because of the small proportion of pore space between the coarse soil particles. Fine-grained soil several feet deep may be slow to fill, but when filled it stores a large amount of water; while coarse-grained soil such as sands provides little storage. On the lighter and more porous soils, as sands and gravels, it is advisable to make light, frequent irrigations. So as to wet the soils rapidly, runs should be short and streams as large as the topography will accommodate. With the heavier soils, runs can be longer and applications can be heavier but less frequent.

Because of the nature of the crop, the time of planting and the length of the growing season, each crop requires water at different periods. Likewise, the water requirement of any particular crop, because of seasonal variations, amount of crop grown, and other factors over which we apparently have no control, will vary somewhat from year to year. The farmer who grows only grain needs large quantities of water for short periods, usually during June and early July, and then he has no further use for water until the next season. Likewise, the farmer who grows only beets and potatoes needs large amounts, but later in the season. With alfalfa, heavy uses are made through the season if the crop is to produce its yearly maximum. By diversification of crops it is possible to reduce the peak demands for water on any particular project.

The water "uses" or requirements for alfalfa, oats, sugar beets, and potatoes, as determined by studies made during the past five years, are shown in Fig. 1. In these graphs are

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Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at Urbana, Illinois, June 24, 1937.

Author: Assistant irrigation engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

shown both total seasonal use and the depth from which the water was taken.

The seasonal use curves for beets and alfalfa show irregularities. The depressed segments are undoubtedly explainable by some unusual condition, such as disease, defoliation, or insufficient moisture. With beets, during three of the past five years, we have had leaf spot, a disease affecting the leaves of the plants. The effects of this disease are most apparent during the month of August. This disease, together with insufficient moisture, undoubtedly is the cause of the depression in the curve of seasonal uses for beets. With the alfalfa, defoliation, or cutting of the crop, and shortage of moisture are perhaps the causes for the drop in this curve.

The relations between crop produced, water use, yields per inch of water used, and water efficiencies on the crops studied are shown in Table 1.

TABLE 1. CROP YIELD, WATER USED, YIELD PER INCH OF WATER USED, AND WATER EFFICIENCIES
Scottsbluff Field Station, 1932-1936

Crop	Yield per acre	Water used,* acre-inches	Yield per acre-inch of water used	Water efficiencies, per cent
Sugar beets	14.78 tons	23.89	0.635 tons	78.2
Alfalfa	5.175 tons	25.89	0.203 tons	76.6
Potatoes	263.04 bu	13.61	18.81 bu	70.1
Oats**	48.69 bu	14.18	3.25 bu	83.0

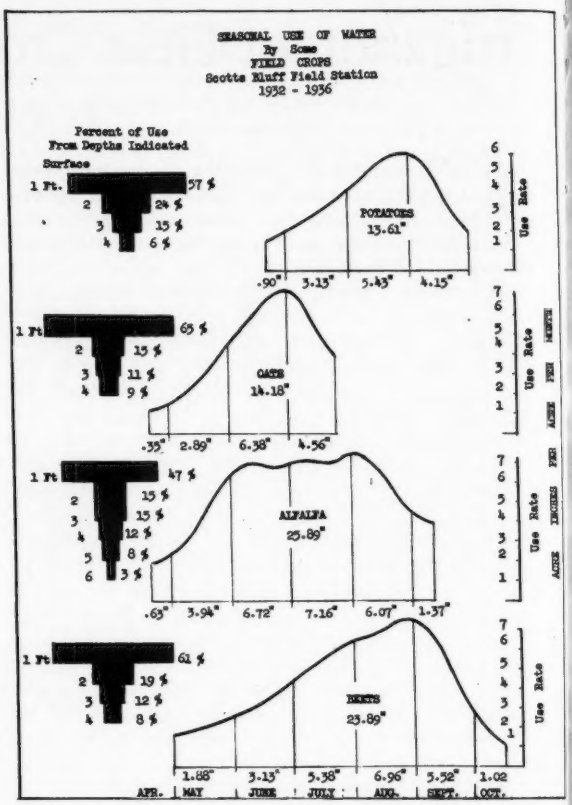
*"Water used" is the amount consumed by evaporation, transpiration, and some small losses due to percolation. Of these, transpiration is undoubtedly the chief source of water dissipation.

**Studied only 4 years, 1933-36. In 1934, due to drought, crop was not irrigated, average yield only 19.3 bu per acre. In 1936, due to drought, crop badly burned before irrigation water was available.

Under irrigation farming the type of soil should govern the quantity of water applied at any single irrigation, while the kind of crop and its stage of growth, climate, and availability of water will govern the frequency. Since soils vary greatly in their capacity to hold water, irrigation practice should also vary somewhat. In actual farming practice it is not advisable to permit the moisture to become depleted to the wilting point, as such a depletion will naturally retard growth. A better practice would be to irrigate at times when there is at least 0.5 in of water available for each foot of depth.

Methods employed in irrigation affect the rate at which water enters the soil. As previously mentioned, row crops are irrigated by furrows, and other crops by flooding. As a means of getting water into the soil, flooding is the more efficient method. With flood irrigation, so as to permit uniform water-spreading, the lands should be leveled to a reasonably smooth surface of uniform slope. By flooding, when it is properly done, the entire soil surface is covered with a sheet of water. This insures all surface soil particles of being wetted and in contact with water for the duration of the run, such a practice materially adding to the rate of absorption. With the furrow method of irrigation the lands need not be leveled to the same degree of smoothness as is desirable for flooding. However, time spent in properly grading the field is of material benefit and greatly reduces the amount of labor involved in managing the water at the time of irrigation. With furrow irrigation only a portion of the soil is covered with water, the total surface so covered depending upon the spacing of the furrows; then, too, some difficulty is encountered in getting an equal amount of water flowing into each furrow.

On the light soil of western Nebraska under furrow



irrigation water enters the soil at the rate of about 1.4 in per hr for potatoes, and about 1.6 in per hr for beets. When flood irrigation is practiced, this rate increases to about 3.25 in per hr.

From the graphs indicating the depths from which the moisture is extracted (Fig. 1), it is seen that the greatest moisture changes occur in the upper 2 or 3 ft of soil. With all crops except alfalfa, fully 80 to 90 per cent of the total water used is taken from the upper 3 ft. In the irrigation of shallow-rooted crops, such as sugar beets, potatoes, and small grain, it is my opinion that if the upper 3 ft of soil is filled with water at each irrigation, there will be sufficient down-drainage of moisture from this upper stratum to supply the plant wants at the lower depth; while with deep-rooted plants such as alfalfa, this depth should be increased to 4 or 5 ft. Consequently it is not necessary to fill the entire soil mass to 6, or even 9 ft, as is sometimes done.

Sugar Beets. Sugar beets are the principal crop grown in the North Platte Valley. Each year the area devoted to this crop is 65,000 to 75,000 acres, and the average production about 12.5 tons per acre. The crop is usually planted about April 20 to 30, and harvested during October. Irrigation is accomplished by running water in shallow furrows 2 to 3 in deep, spaced midway between the 20-in rows. In addition to precipitation, 5 to 6 irrigations of 3 to 4 in each are required to produce the crop. Usually the first irrigation is made about July 5 to 10, with each subsequent application at intervals of approximately 12 to 15 days.

During certain dry seasons, as 1934 and 1936, in order to provide moisture for germination it may be necessary to "irrigate up." This is done by providing furrows be

tween rows and running water in them for such time as it needs to soak laterally to the seed; 2 to 4 hr may be necessary for this. Some growers water in alternate rows, while others prefer to irrigate in every row. Of these two systems the latter is the more efficient.

During the past 5 yr, best crop yields were obtained in 1936, when with six light irrigations the yield (3 plot average), amounted to 18.02 tons; lowest yields, 12.02 tons, were obtained in 1934, the year of extreme drought, when only two irrigations were made. These, however, were heavy (6 to 8 in). Water uses for these years amounted to 23.83 and 18.85 in, respectively. In 1936 each inch of water used produced 0.80 tons, while in 1934 each inch of water produced nearly 0.64 tons. Averaging the values of water used as obtained from the 5-yr study, the seasonal water use by sugar beets amounts to 23.89 in. By months this use is distributed as follows: May, 1.88 in, or about 7.9 per cent; June, 3.13 in, or about 13.1 per cent; July, the month when irrigation begins, 5.38 in, or 22.5 per cent. August with 6.96 in, or nearly 30 per cent of the season's total, is the month of maximum demand; September with a use of 5.52 in, or about 23 per cent of the season's total, is about the same as July; and for the first 15 days of October the use drops to slightly more than 1 in, or 4.3 per cent of the season's total.

Alfalfa. Of the crops reported, alfalfa with a use of nearly 6 in of water, was found to have the largest water requirement. This quantity of water produced field-cured hay at the rate of 5.175 tons per acre, or about 0.203 tons for each inch of water used. Best crop yields were obtained during the season of 1935 when a total (two plot average) of 6.06 tons of hay per acre was produced with a water use of only 23.48 in; this amounts to 0.259 tons for each inch of water used. Poorest yields were obtained in 1936 when a water use of some 22.7 in produced only 4.04 tons per acre, or 0.178 tons for each inch of water used. Irrigation was accomplished by flooding and limited to three applications, varying from 8 to 12 in each, per season, one irrigation being applied to each cutting of hay. Ordinarily the precipitation during the months of April and May is adequate to support the crop until June 1, the time when the first irrigation water is applied.

The nature of the alfalfa plant is such that it will continue to make growth so long as temperature and moisture conditions are favorable. The usage of 25.89 in as reported includes only such water as was used for the three cuttings of hay, and water as consumed in the "off-season" growth, or growth after the third cutting, is not included. Data collected to date indicate that this off-season use, depending on available moisture, temperature and length of period, may vary from about 2 to 3.6 or even 4 in.

Moisture studies indicate that in the production of alfalfa under a system of three irrigations, one for each cutting of hay, each crop of hay usually consumes all the available moisture in the soil within the root zone. Because of insufficient moisture the subsequent crop makes little or no growth until water is applied.

It is the opinion of the writer that, if the alfalfa were irrigated four times for the three crops, in the place of three as practiced, there would result more and a better quality of yields; likewise, more water would be required. Under a system of four irrigations, it would seem advisable to make three waterings for the first two crops, the fourth being applied at a time when the third crop is nearly matured. By such a practice alfalfa fields would have sufficient moisture for the off-season growth; also there would be adequate moisture to permit the plants to enter the dormant period and pass through the winter in a soil reasonably well supplied with moisture. Then too, with the return of spring, there would be ample moisture for the rapid starting of the crop the following year.

From Fig. 1 it may be seen that the water use by alfalfa, by months, is as follows: April 20 to 30, 0.63 in, or about 2.4 per cent; May, 3.94 in, or 15.2 per cent; June and July, with 6.72 and 7.16 in, respectively, are the months of maximum use and during these months 13.9 in, or nearly 54 per cent, of the seasonal water is consumed; August shows a use of slightly more than 6 in, or some 23 per cent; and for the first 10 days of September the use falls to 1.37 in, or slightly more than 5 per cent of the season's total.

Potatoes. Seemingly the potato is a plant which does not thrive well under conditions of high temperature; best growth occurs with temperature ranging from about 50 to 80 F. The light sandy soil and climatic conditions of the North Platte Valley are very suitable for growing potatoes; next to sugar beets potatoes are the principal cash crop grown in the Valley.

Potatoes are irrigated by the furrow method. The furrows 6 to 8 in deep, are made midway between the 30 to 36-in rows, at a time prior to the first irrigation. From four to five irrigations of 3 to 4 in each are required each year, depending upon the amount and distribution of the seasonal rainfall. After the first irrigation, which for the late potatoes, is about the middle of July, water should be applied frequently enough so that at no time will the plants be allowed to suffer from drought. So as to permit ample time for the proper ripening of the tuber, the last irrigation should be made about one month before harvest.

As with sugar beets, during certain dry seasons, in order to provide moisture for proper germination, it may be necessary to irrigate potato land prior to, or soon after, planting. While irrigation after planting is done by many growers and has been successful, others prefer to furrow and irrigate, then plant the seed in the moistened furrows. This practice will greatly reduce the hazard of having the seed in dry soil, which frequently results when irrigation is done after planting.

During the course of our studies best crop yields, 410.4 bu per acre, were obtained in 1933; poorest yields, 146.0 bu per acre, were obtained in 1934, the year of extreme drought. Average water use for these years was 18.4 in and 11.3 in, respectively. As shown in Table 1, water use (average for 5 years) for potatoes amounts to 13.6 in. On a seasonal basis, as shown in Fig. 1, this use was distributed as follows: For the period June 15 to 30 the use is 0.90 in, or about 6.6 per cent; July, 3.13 in, or about 23 per cent; August, with some 5.4 in, or about 40 per cent, is the period of maximum usage. September, the period of ripening, with a use of 4.15 in, or slightly more than 30 per cent, is the second high month of usage.

Oats. In the irrigation of oats and the other small grains, the common practice is to irrigate by flooding. Ordinarily oats are planted about April 20 to 25 and harvested around July 25. Each year, depending on the amount and distribution of the seasonal rainfall, the crop requires two to three irrigations of 4 to 5 in each. Usually the spring precipitation is sufficient to carry the crop until late May or the fore part of June, the time when the first watering is applied. Subsequent watering should be made at intervals of 12 to 18 days.

During the past 4 yr, because of the limited acreage and the availability of irrigation water, there was considerable variation in the irrigation treatment. This irregularity of irrigation, and the absence of spring precipitation, resulted

in great extremes of soil moisture and crop yields. For the years 1933 and 1935, by irrigation and rainfall, soil moisture conditions favorable for crop growth were maintained from time of planting until harvest. Average yields for these years were some 68.5 bu, and water uses amounted to about 16.9 in. During the years 1934 and 1936, because of drought, average yields of only 29.1 bu per acre were obtained; uses for these dry years was some 11.4 in. On the basis of averages, as obtained during the past 4 yr of rather adverse conditions, the total seasonal water use by oats amounts to about 14.2 in. (Because of adverse conditions for two of the four years of study, presumably this figure, 14.18 in, is low; 16 to 17 in may be more nearly correct.) When segregated into months this use is as follows: April 20 to 30 only 0.35 in, or about 2.5 per cent; May shows a usage of 2.89 in, or more than 20 per cent; June with a use of nearly 6.4 in, or some 45 per cent, is the month of maximum usage; and the period July 1 to 25 with nearly 4.6 in, or 32 per cent, is the period of second high usage.

From the studies just described, assuming that the crops studied are fairly representative of their group, it is concluded that water requirement for oats would be reasonably representative for the small grains; water requirement for late potatoes, except for time of use, would be about the same as for the early variety. In general, it may be said that such crops as early potatoes and small grains require water early in the season, the period from May to the middle of July, while sugar beets and late potatoes require most of their water during the latter part of the season—July to September. Alfalfa, pastures, and other perennials do best if water in liberal amounts is supplied throughout the entire growing season.

Thus it is seen that in the selection of the crop to be grown due consideration should be given to the water supply and its availability during the season. Under ideal conditions of irrigation a plentiful supply of water would always be available, and all the above crops could be grown with safety. In practice, however, such conditions seldom exist. Seldom, if ever, does the periodic flow of a stream coincide with the periodic crop requirements. The flow in rivers and streams from which the water is usually taken varies from season to season, and unless there is adequate storage in reservoirs of ample capacity, or reliable pumping systems, there is not a uniform flow of water throughout the season.

In planning operations under irrigation farming, the farmer should, to a large extent, base the acreage to be devoted to a particular crop on the expected water supply for the season. Such practices, if followed consistently, will greatly increase yields and naturally lessen the worry of nursing the crops to maturity.

New Mechanical Technique to Develop Vegetative Cover

(Continued from page 12)

pasture development and the reclamation to pasture of severely eroded and moderately gullied land. There are certain definite limitations in the Athens area to the use of the mechanical methods described below in their application to successful pasture work. It is important that these methods be limited to reasonable slopes and that they be practiced only on soil series having a subsoil productive enough to sustain Bermuda grass with the help of the mechanical treatment given and fertilization. The subsoiling and grass sprigging pasture treatment described below is used alone or in combination with wide interval terraces depending on the land slope, extent of gullies, soil condition and existing vegetative cover.

A field chosen for pasture treatment is staked in contours at vertical intervals of from 2 to 4 ft depending on its condition and whether wide-interval terraces are used. A double-contour subsoiled strip about 10 ft in horizontal width is then made by one round with the subsoiler. This strip is then sprigged with Bermuda grass and treated with complete commercial fertilizer in the manner described above. The double contour furrow is subsoiled to take advantage of the full spreading width of one trip with the manure spreader. Cover is then given by a disk or drag. In cases where the fields treated are in exceptionally bad condition as to soil and topography, a mulch of any organic material available may be distributed over the covered grass by the manure spreader. The cost of this type of work varies from $4 per pasture acre treated under favorable circumstances to a maximum of $12 per acre under conditions most unfavorable to any type of mechanical work.

These various methods were developed in the Athens, Georgia, Soil Conservation Service project where sufficient government-owned equipment was available to use the machine best adapted to each type of work described. In cases where such mechanical equipment is not available, it is possible to adapt these methods to a minimum of accessory equipment. The minimum equipment required to perform any of the operations above described on a construction scale would consist of one 40-hp tractor, one 3-tooth subsoiler, one manure spreader, and one disk or drag.

In order to permit a construction program using the above methods for sprigging grasses in all seasons and to simplify the needs for covering implements in any season, the following special practices have been developed. The addition of two small wing plow shovels to each of the standards holding the main teeth of the subsoiler permits widening a surface furrow at no extra cost. When these furrows are sprigged with the manure spreader, a large proportion of the grass sprigs come to rest in these surface furrows. Cover deep enough to give protection against summer drought or winter cold can then be provided by the use of a simple timber drag which breaks down the ridges left between the surface furrows. The double-wing plow shovels should be attached to a bracket so that they are adjustable on the subsoiler standards in such a manner that they can be set to cut the required furrow for any depth of cut by the subsoiler.

Although these practices have been developed on a Soil Conservation Service demonstration project, the cost reduction effected by the methods described have resulted in considerable interest in such methods by nearby county terracing cooperatives. Their interest is mainly in developing such treatment into a power market for their machines during seasons when terraces cannot be constructed. Certain farmers in the Piedmont who had access to a manure spreader have used the pasture development methods with some success. They made the necessary preparation for sprigging the Bermuda grass with ordinary farm tools and farm power.

This preliminary report is not intended to do more than suggest a new mechanical technique for the economical development of vegetative cover under certain conditions. It is hoped that trials of the methods suggested may result in the full exploration of their possibilities.

An Analysis of the Farm Structures Market

By G. B. Hanson

IT SHOULD be recognized at the outset that the subject of this paper is so broad in scope and varied in detail that no brief study of this kind can be expected to establish clearly and completely all basic data bearing on the subject. Nor should it be supposed that this short analysis will, in itself, point out a specific remedy for the notorious illness of the farm structures patient.

If, however, certain fundamental data and relationships can be pointed out and made of record, and if relatively recent new trends in agriculture, which affect the structures market, can be spotlighted, it is felt that this focusing of attention on several important aspects of the problem may possibly encourage future contributions, which will gradually lead to a more satisfactory understanding and a more effective solution to the problem of securing better farm structures.

Importance of Farm Structures Market. Many of us intimately concerned with and actively seeking better farm structures appreciate the comparative size and importance of this market. The pressure of day-to-day business, however, oftentimes obscures the picture of the market in its entirety, and sometimes causes us to neglect important angles of the market situation.

Looking at the national farm plant as a whole, and taking into account present-day replacement costs, as well as the paucity of farm construction in the 1931-34 period, the value of all farm buildings today appears to be something just under 12 billion dollars[1]. This is, of course, a very substantial amount of property, and with the exception of the land, it is the farmer's largest investment item.

The repairs, replacements, and improvements for this 12 billion dollars' worth of buildings constitute the farm structures market. In a good year this market amounts to around 500 million dollars, as nearly as can be ascertained from available statistics. While this is a very substantial market, there is ample evidence that it should be substantially larger, particularly over the next few years, in order to return farm buildings to anything approaching a satisfactory condition for comfort and efficient production. Granting a reasonably satisfactory national farm income, it can be shown that such an increase in structures expenditures would not be burdensome. In fact, increased expenditures must be made unless we are willing to accept a further serious depreciation in the value and physical condition of farm buildings.

A study of all classes of farm expenditures will readily show that a moderate increase in expenditures for buildings can be made without difficulty. With cash receipts amounting to about 10 billion dollars in a good year, it is noted that less than 5 per cent of this amount goes for buildings, including all repairs, replacements and improvements. This 5 per cent of income not only supplies shelter for the farmer and his family, but it also provides shelter and production facilities in service buildings for the whole farm business. The extreme economy of farm structures is better appreciated too when we recall that city families customarily spend three to four times as large a share of their income for family shelter alone.

Objection to sizeable farm building expenditures is often made on the ground that farm income just isn't large enough to support the building improvement. This is an understandable reaction because a major improvement may oftentimes amount to more than all cash taken in on a given farm in a whole year. The fact that most farmers have to meet only one major building improvement in their lifetime, however, is not taken into account. It should be remembered that good modern farm buildings will last a lifetime with very low upkeep. And even with the large proportion of less substantial buildings in existence today, the farmer is, on the average, spending less than 5 per cent of his income on buildings. It would thus seem plain that the factor of cost of farm buildings has sometimes been exaggerated in our thinking. Taking these different factors into account, it would seem that, with a properly organized program, farm structures interests should be able to convince the farmer of the desirability of using a somewhat larger portion of his income for the relatively permanent comforts and greater efficiency of modern farm structures.

Just how this may be accomplished is a major problem in itself. It would seem, however, that the plan for a national "Farm Structures Institute" as proposed before the Farm Structures Division at the last annual meeting of this Society, is a big step in the right direction. It now seems clear that the independent efforts of widely scattered structures interests can not possibly exert the broad and forceful influence needed to revive and substantially increase volume of farm building to a point commensurable with the size and importance of this 12 billion dollar investment. However, an aggressive "overhead" organization could, it is believed, develop a sound and vigorous program of farm structures promotion that would capture the attention and win the active cooperation of farm leaders, the agricultural colleges, the farm press, and others, and that would cause farmers to invest a substantially larger share of their income in building improvements. A suggested program for a farm structures institute is now being developed. If substantial support of the program is forthcoming, a vital force can be marshalled to increase the amount of farm building.

Effect of New Agricultural Trends. Agriculture in its broader aspects changes so slowly that it is often regarded as a fixed national institution with fixed requirements and fixed buying habits. Careful analysis, however, readily explodes this theory, and shows that in farm structures, as in other products and services, the farmer of today is demanding modern materials and products to meet his modern, changing needs or desires. Farm structures interests will, therefore, profit most by being alert to new trends, so that their services may be altered as the occasion demands.

It has long been common practice to fit services and marketing methods to the local or regional requirements of a particular type of agriculture. For example, farm services supplied in a northern dairy region will be carefully designed to fit the exacting requirements of this particular market. For most effective results, the same principle is

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Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Illinois, December 1, 1937.

Author: Agricultural engineer, Portland Cement Association. Mem. ASAE.

[1]Figures used throughout this article refer to buildings only. It is assumed, however, that principles developed and trends indicated will also be applicable to fencing and other structures items.

employed in approaching any of the dozens of other special farm markets existing because of a particular type of agriculture prevalent in a given region.

There are now, however, three relatively recent factors of national importance which are affecting the farm structures market, and which should, therefore, receive sympathetic attention and cooperative action from all forward-looking structures interests. First of all, it is noted that recent changes in crop and management practices are having an effect on the structures market. In the southern and southeastern part of the country, for example, there has been a reduction in the last few years of several million acres in land devoted to cotton. After more than 25 years of exhortation and teaching by the agricultural colleges and experiment stations, an appreciable amount of diversification of crops is beginning to be realized. If this favorable trend can be continued, with more millions of acres going out of cotton production and into corn, soybeans, wheat, oats, legume hay, peanuts, and sweet potatoes, a more substantial and attractive living for this whole section of the country will result. The more substantial building requirements of diversified farming and better living are bound to create large new markets for building materials.

Recent shifting of large acreages to a system of contour farming has also clearly enlarged certain markets. Other phases of soil erosion control and water conservation, such as the widespread building of small dams, have also created sizable markets for building materials. In certain localities a substantial acreage is being improved by irrigation, in others by drainage improvement work. Wherever projects of this nature develop, land is being converted to a higher use, and important markets are created for fencing materials, tile, lumber, cement, steel, and other materials. Alert and aggressive structures interests have tied in with these programs to advantage in nearly all sections of the country.

The second factor of national importance which may be expected to influence the farm building market is the farm chemurgic movement which has grown so amazingly during the past two or three years. This movement is attracting much favorable attention. It is the hope of the National Farm Chemurgic Council, and many state councils now organized or in process of organization, that many of the common farm crops or new crops can be developed to serve as raw materials for American industry. Definite and far-reaching progress along this line has already been made, one of the most important developments to date being the production of paper pulp from southern pine. As the industry expands, thousands of farmers in that area will be furnished additional work and cash income. It is planned that the timber harvest will be managed on an annual cropping basis. Many expect that, within this generation, the value of the annual timber crop for the pulp mills may exceed that of the annual cotton crop.

Another crop which has grown in importance at a fantastic rate in the last few years, and which promises even greater things for the future, is the soybean.

Other farm chemurgic possibilities now in process of active investigation and development are the sweet potato for starch, industrial alcohol from farm crops, tung oil, and corn for a variety of purposes. Providing crops can be grown profitably at a cost lower than present sources of raw material, it is felt that important new agricultural markets can be created through farm chemurgy. And if farm products come to be an accepted source of raw materials in industry, total farm income should be increased and stabilized because of the increased quantity and diversification of crops.

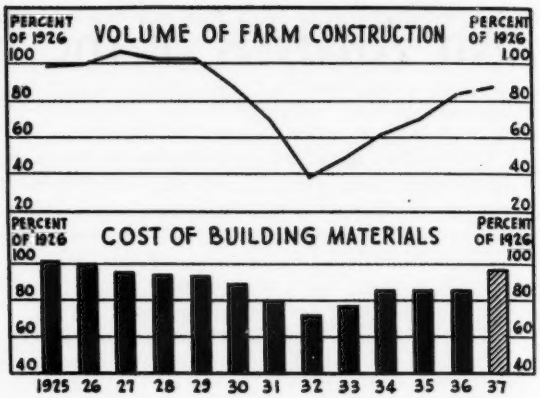

FIG. 1 PHYSICAL VOLUME OF FARM CONSTRUCTION COMPARED WITH COST OF BUILDING MATERIALS

The farm tenancy situation is the third factor of national importance which should be of interest and concern to farm structures people. The study of this problem has been given added impetus in recent years, and a brief summary of some of the known facts will be useful. For the country as a whole, farm tenancy has increased gradually from about 25 per cent in 1880, to more than 42 per cent at the present time. In terms of our national agriculture, it is thus known that 42 per cent, or 2,800,000 of our 6,800,000 farm operators, are tenants. Likewise, it is known that these tenants operate farms having a value of about 33 per cent of all land, or 12 billion dollars out of a total of 36 billion dollars. (Figures refer to value of land and buildings only.) Also, in terms of land area, tenants operate 47 per cent of the farm acreage, or 499 million acres out of a total of 1,054 million. These facts are of concern to us because this large proportion of tenancy affects the farm structures market in two important ways. In the first place, tenant-operated farms are usually neglected as to both land and buildings. This is well known, but it is doubtful if the seriousness of the situation is generally realized. These tenant farms are most often allowed to depreciate well below the average for the community. It will be noticed that fences on these farms are in very poor repair—many will be gone entirely. Buildings will ordinarily need major repairs to make them anywhere near adequate. For the country as a whole, this means that a market for building materials running into several hundred million dollars has been lost because of farm tenancy. If a large share of these tenants were transformed into owner-operators, an enormous market would be created immediately, as pride of ownership began to assert itself in repairs, replacements, and general building improvements. It is undoubtedly to the advantage of the farm structures interests to cooperate actively with any realistic project seeking to increase farm ownership and decrease tenancy.

The second reason for our concern with tenancy is that in areas having a high proportion of tenancy, it is necessary to plan building services and marketing methods in a different manner from that done in an area where farms are predominantly owner-operated. There are many important agricultural areas where farm tenancy is prevalent to the extent of 40 to 60 per cent or more. Farm structural services which have been designed primarily to reach the owner-operated farm will be seriously out of focus and inefficient in these areas. If farm structures improvements are to be influenced to any great extent in the

tenant farm areas, special techniques must be developed to reach the absentee owner.

Factors Influencing the Volume of Farm Building. The inherent character of the farm business makes farm construction basically different in several respects from that of other types such as urban residential or industrial building.

In one important way though, farm building is like other types of building in that most farm building takes place when building costs are relatively high. Moreover, farm building like other types tends to decrease as building costs decrease and increases as costs increase. To the uninformed this may seem like a remarkable and incredible state of affairs. The reason for it, however, appears to be that in farm building, as in other types, the cost of building has relatively little to do with the volume of building, as will be shown presently.

Fig. 1 provides a comparison between physical volume of farm construction and cost of building materials over the past 13 years, using 1926 figures as 100 in both cases. Physical volume of farm construction is computed for each year as a percentage of 1926 volume and is obtained by correlating the annual dollar volume of building with the changes in cost of building materials for each year. The annual dollar volume of farm construction was obtained from U. S. Department of Commerce data as shown in Fig. 3. Cost of building materials is derived from U. S. Department of Labor figures based on the cost of the following materials: Lumber, cement, steel, paint, brick, tile, and plumbing and heating supplies. Costs are averaged for each year and are shown as a percentage of the 1926 average, which is figured as 100. Figures for 1937 are preliminary estimates by the author.

Following the curve in Fig. 1, which shows volume of farm construction, it will be noted that most farm building took place in the 1925-29 period when building costs were relatively high. The chart also shows that both volume of building and building costs declined substantially during the 1930-32 period. Building, which had averaged more than 100 per cent of the 1926 volume all through the 1925-29 period, began its rapid descent in 1930. It declined to a low of about 40 per cent in 1932 in terms of the 1926 volume. At the same time cost of building materials had declined from an average of 94 per cent in 1929 to 72 per cent in 1932. This is an interesting part of the curve because popular belief is that if building costs are decreased there will be an immediate increase in volume of building. As shown here, however, there was no increase in building as costs were reduced, but instead volume of building decreased steadily as cost of building drifted lower. Beginning in 1933, both costs and volume of building started a trend upward which has continued to the present time. Costs have now increased until they are about 97 per cent of the 1926 average and volume of farm construction appears to be just under 90 per cent of the average for that year. Indications now are that farm building costs for next year will remain at approximately the present level and that there will be a further increase in the volume of construction.

Referring to Fig. 2, it is shown that over a 23-yr period, the largest volume of residential construction was also completed when building costs were relatively high. In this chart the volume of residential construction is based on a U. S. Department of Commerce estimate, which in turn was based on reports of the U. S. Bureau of Labor Statistics. The number of family units shown in this estimate each year exceeds the number estimated by certain other reliable agencies. This seems to be accounted for mostly by the fact that the Department of Commerce estimate covers construction of very low cost dwellings not considered in certain other estimates. Cost of building materials is derived from data from the U. S. Department of Labor and, as in Fig. 1, reflects average annual costs of lumber, cement, steel, brick, tile, and plumbing and heating supplies. Yearly averages are shown as a percentage of the 1926 average figured as 100. Figures for 1937 are preliminary estimates by the author, based on averages through the first 8 months of this year.

Inspection of the chart in Fig. 2 shows that the drop in residential construction in 1920 is the only case where it would seem that rising construction costs reduced volume of building. Since building costs advanced so sharply that year, it would not be surprising if high costs were an important factor. It should be remembered, however, that 1920-21 were years of drastic decline in industrial production and bitter labor strikes, and these influences may have been fully as important in reducing volume of construction as were rising construction costs. In any case, the important conclusion to be drawn is that residential construction also demonstrates the principle stated above.

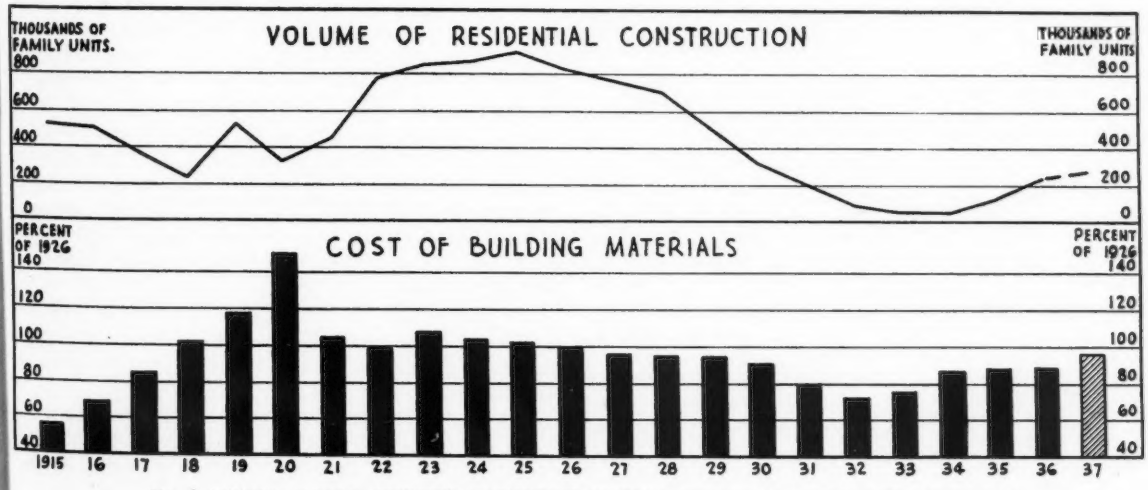

FIG. 2 PHYSICAL VOLUME RESIDENTIAL CONSTRUCTION COMPARED WITH COST OF BUILDING MATERIALS

that large volume of building takes place during periods when building costs are relatively high, in this case in the 1922-29 period. And here again it is noted that building costs and volume of construction declined together through 1932; then both costs and volume of construction trend upward to the present time. To demonstrate the difference in volume of residential construction when costs are relatively high, as compared with years when costs are relatively low, another measure can be obtained from these curves. Computing an average for the 11 years of relatively high building costs it is found that 666,000 family units were built per year; in the 11 years of relatively low costs, however, an average of only 276,000 family units per year were built. In other words, about two and one-half times as much building, on the average, took place in years of higher costs.

It will be recalled that Fig. 1 indicated that the volume of farm building was little influenced by the relative cost of building. Referring now to Fig. 3 it is noted that the dollar volume of farm construction follows the annual trend in farm purchasing power with amazing agreement. In this chart index numbers of farm purchasing power represent the ratio of prices farmers received to prices they paid each year, with the 1910-14 average equal to 100 (U. S. Department of Agriculture data). The 1937 figure is the average of the first six months. Dollar volume of farm construction includes both service buildings and dwellings, and for the years through 1934 is based on data from the U. S. Department of Commerce. The years 1935 and 1936 were estimated by the author from preliminary governmental estimates. The 1937 figure is a rough preliminary estimate by the author from the year's farm building trend compared with 1936.

Study of these curves shows that all through the 1925-29 period, when farm purchasing power was above 90 per cent of the 1910-14 average, the volume of farm construction exceeded 450 million dollars per year. But as income and purchasing power decreased from 1930 through 1932, there was a consistent and regular decrease in volume of building, until in 1932, with purchasing power at only 60 per cent of the prewar level, volume of building amounted to only about 130 million dollars. As purchasing power increased from 1933 to date, it is noted that volume of building increased steadily and in proportion to the improvement in income. This regular and immediate increase in farm building as purchasing power improved, is one of the important and favorable characteristics about farm building which is different than most any other type of building. Also it should be noted that whereas residential building declined 90 per cent from 1926 to 1932, the volume of farm building declined only 60 per cent in the same period.

It was stated above that a very substantial gain in farm building would have to be realized if buildings were to be returned to anywhere near a satisfactory condition. Fig. 3 provides a graphic portrayal of the basis for this statement. It will be noted that during the period of 1930-36 expenditures for farm buildings dropped so severely that a building requirement of about one billion dollars accumulated. In other words, a one billion dollar expenditure for farm building is now urgent, solely to wipe out the accumulated repairs and replacements of the depression period. When normal building requirements of the future are added to this amount there seems ample evidence to support the statement made above, that annual expenditures for farm building must be substantially increased over the next few years if buildings are to be maintained in anywhere near satisfactory condition. Any

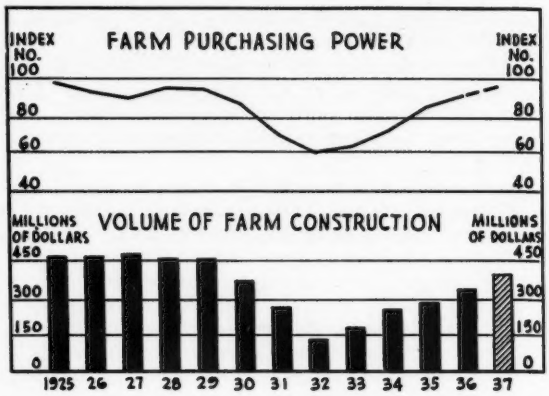

FIG. 3 DOLLAR VOLUME OF FARM CONSTRUCTION COMPARED WITH FARM PURCHASING POWER

alternative course means the acceptance of a reduced building valuation, permanent loss of a substantial share of farm real estate values, and, most disturbing of all, a lowered standard of farm living. This situation has been fully realized by many of the better farmers and by some of the larger and more progressive institutional landlords in this country. These people have not only understood the dangers, but have taken vigorous action to protect their interests. Institutional landlords alone have spent many millions of dollars on farm structures' rehabilitation during the past few years, feeling that these repairs and replacements are the best possible protection for their farm real estate investments. If the large majority of farm owners can be influenced toward the same sound and prudent action, not only to protect and preserve their real estate, but to secure more comfortable and more efficient buildings for a better farm living—if these things can be brought to pass—the extension specialists both in public service and private industry will have accomplished a service of untold value to the nation.

How Pipe Bends Affect Flow of Water

STUDIES of the flow of water through 6-in pipe bends, by the late David L. Yarnell of the drainage division, U. S. Bureau of Agricultural Engineering, have contributed new facts of value in making efficiency tests of irrigation pumping plants and in designing pumping equipment.

The results are reported in detail, with charts and photographs of experimental set-ups, in U. S. Department of Agriculture Technical Bulletin 577, "Flow of Water Through 6-inch Pipe Bends." The investigations covered bends of various degrees and included studies of velocity, pressures and currents in the upstream and downstream tangents as well as in the bends. Celluloid pipe was used for the bends and the adjacent sections. All bends were found to obstruct flow more than an equal length of straight pipe.

It is suggested that in most installations at least one pipe bend can be calibrated for use as a flow meter and a manometer constructed by which discharge of the pipe can be read directly.

Because of the greater roughness of their inner walls, bends in cast-iron pipe doubtless cause greater loss of head than those in celluloid pipe, but the tests with celluloid pipe suggest the relative effects.

Irrigation Systems and Their Application

By J. P. Schaenzer

AS THE years go by, irrigation of crops to supplement the rainfall in the humid regions of the United States is receiving more and more favorable acceptance. Annually the acreage increases. In 1936 a committee of the Society reported 33,000 acres as irrigated in seventeen humid states. Further investigation in 1937 revealed an increase of 4,500 acres, or 22 per cent, in ten of these same states. If the increase was the same for the other seven states, it is not unlikely that 40,000 acres were irrigated during the past season. This increase in acreage is reported in areas having a recorded average annual rainfall of 20 in and more.

I wish to call attention to Extension Circular 754, entitled "Pump Irrigation," prepared by Ivan D. Wood and published by the University of Nebraska. It is Mr. Wood's observation that many men are irrigating land under seemingly favorable conditions, yet they have made no favorable progress. Others in the same community have prospered through its use. He lists the points of similarity in the practices of the irrigators who succeed, and the usual mistakes made by those who fail. I shall not even try to mention these pertinent factors which lead to success, but merely desire to call attention to the fact that such do exist and must be considered carefully for each individual irrigation installation.

Many different methods of irrigation have been developed. Regardless of the method used, it is all-important that the equipment installed be a coördinated outfit consisting of a motor, pump, mains, and laterals which will meet the requirements of both the water supply and the field demands. Unless this is done it is impossible to have satisfactory, efficient, and economical operation.

Time does not permit a detailed technical discussion of all the methods of irrigation. For that reason brief descriptions of the equipment and operating characteristics of only those systems commonly used will be presented. It should also be remembered that many of them are adapted for both permanent and portable installation.

Revolving Sprinklers. Irrigation by means of the revolving sprinkler system has come into extensive use during the past five years. The chief advantages of this method are that it can be used on rolling topography; the land does not need to be leveled; because of the slow application there is little danger of erosion; nor is any difficulty encountered with the water distribution if the land is practically level. If a portable system is installed, the installation and operating costs are low. Both of these latter factors are directly related to the acreage irrigated. For operating such a system, each sprinkler requires from 1 to 1½ hp.

When first introduced, an underground feeder pipe system was recommended and used. Riser pipes and sprinklers were connected as the water was needed. The installation cost was high. To reduce this initial expense and to provide greater flexibility, many farmers are using a more or less permanent main feeder line with portable, light-weight laterals. The latter are easily moved from place to place as the water is applied to the land. The pipe used for the laterals is of light weight, 16 gage, spiral or straight, seam welded, and comes in 20-ft lengths. Each section has a threaded outlet for attaching the riser and sprinkler head. The ends of the pipe come equipped with couplings which can be connected or disconnected rapidly without the use of tools.

Welded pipe is also available for the supply lines. These may be placed above or below the ground, and the ends may be joined by couplings or welded. Risers must be provided to enable connecting, by means of heavy duty hose, to the laterals. Caps or valves may be used on the risers to control the water.

Double-nozzle sprinkler heads have been developed. One of these covers the outer area of the circle while the other irrigates the inner section. A discharge of 15 to 20 gal per min, and covering a diameter of 90 ft at 40 lb pressure, is common practice. One revolution or less per minute is a desirable speed for the sprinkler. The diameter of the lateral pipe line should be such that the pressure will be the same for each sprinkler head. It is suggested that a pressure gage be installed at the end of each portable line. A gate valve placed in the last sprinkler riser will permit flushing the system and cleaning the sprinkler when necessary.

As to field layouts, many different arrangements or combinations of feeder and lateral pipe lines are possible. The layout used depends upon many factors such as acreage covered, available water supply, available power, labor involved, and the time element. Some of the more popular equipment arrangements when using portable laterals are known as single-line operation, alternate-line operation, split-line operation, and field-hydrant operation. For single-line operation, the main feeder line may be placed next to a fence between two fields. Only one lateral is attached at a time, and moved to a new position when the desired amount of water has been applied.

Two portable sprinkler lines are used for alternate-line operation. The primary motive for using this method is to keep the sprinkler system in operation with a minimum loss of time while moving the portable equipment.

In the split-line system, two lines are put in service simultaneously. The pressure main is provided with tees at regular intervals where the portable sprinkler lines are connected. The two shorter lines require less power or have less friction losses than a single line of the combined lengths.

Because of the initial cost, field hydrants are not used extensively to control the flow in the laterals. If installed, they are spaced at such intervals in the pressure main that each hydrant will serve six or more areas. The chief advantage of the hydrants is that they permit continuous operation of the irrigating system.

The revolving sprinklers are usually placed at 40-ft intervals in the portable lateral. With this spacing, a strip practically rectangular in shape is irrigated every time a sprinkler line is placed in operation. According to tests conducted by the California Agricultural Experiment Station, for one type of sprinkler the laterals should be moved a distance of 50 ft. This provides for considerable over-

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Presented before a joint session of the Power and Machinery, Soil and Water Conservation, and Rural Electric Divisions at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Illinois, December 1, 1937.

Author: Assistant director, Committee on the Relation of Electricity to Agriculture. Mem. ASAE.

lapping of the spray, but also gives excellent distribution of the water on the land.

Low Pressure Perforated Sprinkler Pipe. The chief advantage of this method of irrigation is that it can be operated at low pressure, ranging from 2 to 16 lb. The portable sprinkler lines average from 200 to 600 ft in length and irrigate a rectangular strip of ground. The galvanized pipe used for the laterals is of light weight and has slip joints so that it can be moved easily and readily. Because of the flexibility of the joints, it lends itself readily to use on uneven rolling ground. Pipe 3, 4, and 5 in in diameter is commonly used for the laterals, while larger sizes of the light-weight pipe are used for the mains or feeder lines.

Small perforations are placed in a row the length of the pipe. The perforations are slightly staggered so that a strip of land is watered on both sides of the pipe. The width of the strip covered depends upon the pressure of the water.

Eyelet Hose. A recent development, also operated at low pressure, is eyelet hose, and so far has been used primarily in orchards. Four tiny eyelets are placed in a circle around the hose every 2 ft. The pressure of the water per square inch determines the quantity of water used and the width of the strip of land irrigated.

Overhead Sprinkler Pipe System. Elevated pipe lines are supported on posts 1½ to 6 ft in height, and about 50 ft apart. The pipe is drilled and tapped for a fine-bore brass nozzle every 3 or 4 ft. When water is pumped into it at 40-lb or more pressure, tiny streams of water come from the nozzles which are perpendicular to the pipe and parallel to each other. A valve should be placed at the end of each nozzle line. Frequent flushing will keep the pipe lines free from sediment.

A vertical pipe or riser connects the nozzle line to the underground supply line. To irrigate the land on each side of the pipe or only a narrow strip on one side of it, it is necessary to be able to revolve the pipe on its axis. This may be done either manually or automatically with a water-power-operated oscillator. The maximum amount of rotation is about 120 degrees. Depending upon the pressure, about one inch of water is supplied to the soil in from 6 to 8 hr.

Some growers use portable equipment. This reduces the installation cost, but increases the labor required in moving the nozzle lines from field to field. The pipe may be laid upon the ground, low posts, or special devices. It does have the advantage of being out of the way for field work. Because of the constant moving, portable installations will not have the length of life of equipment installed permanently.

The nozzle lines should run parallel to the crop rows. The length installed may be as long as 700 ft. Long lines are satisfactory if a large area can be devoted to one crop or crops requiring similar cultural treatment. The amount of water available at one time also has a direct bearing upon the length of pipe which can be put in operation. Each nozzle will deliver about 12 gal of water per hour at 40 lb pressure.

To irrigate an acre with overhead pipe requires 870 ft of nozzle pipe spaced at intervals of 50 ft. If operating conditions permit, installation costs can be reduced by using short mains and long nozzle lines. All feeder lines should be of ample capacity to meet the maximum water requirements. Excessive friction losses or high pumping pressure will reduce the efficiency of the system materially. Galvanized wrought iron pipe is best for diameters up to 3 in. Black pipe is usually installed when larger sizes are needed. Provision should be made for draining the pipe to prevent damage from freezing.

Surface Irrigation. Land to be surface irrigated must be smooth so that no areas will be exposed or excessively covered when water is applied to it. Irregularities in the surface of the ground must be leveled. This may prove costly, in addition to exposing subsoil which may be unproductive. The slope of the land must be determined which may be either too much or not enough. A gradient of 2 to 4 in per 100 ft is considered satisfactory under ordinary soil conditions.

Common methods of surface irrigation are furrow and flood. Furrow irrigation is used extensively in the production of row crops. The water is carried in furrows between the crop rows. These are supplied by head ditches, gated, low-pressure, light-weight, portable surface pipe, or other similar means. The slope of each furrow should be such and the quantity of water entering it such an amount as to reach the lower end as quickly as possible without soil erosion. If the land is too flat it may be necessary to use hose or portable pipe to carry the water part of the way down the furrows. The quantity of water applied should be watched closely to avoid any waste.

It is difficult to secure an even distribution of water among all the furrows. When numerous furrows are irrigated simultaneously, it is advisable to place a short piece of pipe, one for each furrow, temporarily in the wall of the head ditch and so convey more nearly equal quantities of water to all of them.

As a rule, the water should not go below the roots of the plants. The depth of penetration can easily be determined by a soil examination. Although fields with furrows 500 ft in length have been irrigated successfully, the shorter furrow lends itself more readily to this method.

In the flooding method of irrigation, the water is permitted to flow over the land. The area covered is known as a check or basin and is surrounded by an embankment to hold the water. The shape of the check may be square, rectangular, or follow the contour of the land. It is especially adapted to legume, pasture, and orchard irrigation.

It is desirable to turn a large stream of water into each basin when irrigating so as to flood the entire area in the least time. Thus similar penetration is secured throughout the entire check. When the desired depth of water has been reached, the water is turned into another basin.

Porous Hose Irrigation. Canvas or tight-weave fabric hose is used to convey and distribute the water. One end of the hose is attached to the water supply line while the other end is closed. As the water inside the hose reaches a pressure of 15 to 20 lb, it oozes through the walls. As it comes out slowly, little difficulty is encountered by erosion. It is also adapted to irregular ground, for it will convey water with fairly uniform results over elevations of several feet. The procedure followed is similar to the methods described previously. It is preferable to have the supply line at the high side of the field as better distribution is obtained if the hose extends down grade or on the level.

Different weights of canvas should be used in the construction of long lines of hose. Duck of 8, 10, and 12-oz weight is satisfactory for 2½-in diameter hose, which is most commonly used. Each 100 ft of hose requires a capacity of 10 gal per min. Lengths up to 600 ft have been found satisfactory. The time required to apply one inch of water depends upon the pump capacity and the length of the row.

Some Dynamometer Tests of Tracks and Rubber

By W. A. Harper

BASED ON the principle that facts are essential for good designing and selling, many dynamometer tests have been made at the Caterpillar Tractor Company's proving grounds and this paper discusses certain phases of measured performances of tractors and wagons equipped with tracks and low-pressure pneumatic tires. The Company manufactures track-type tractors and rubber-tired auto patrols, the latter being driven by two or four wheels equipped with rubber tires. The auto patrol is specially designed for road maintenance, construction, and similar work. Because many auto patrols are being used for pulling loads at the drawbar, questions frequently have been asked about drawbar capacities, not only to be used as such, but to help interpret the amount of work that can be accomplished when the power is applied through the moldboard.

Since track-type tractors have been used in all kinds of traction conditions for many years, the performance characteristics of these machines are widely known. It is only natural to expect that this company should use track-type tractors as a basis or standard for comparison, because the foundation of its business is track-type tractors.

It is common knowledge that the amount of slip, or travel reduction, for any tractor varies with the soil surface and drawbar pull. On a muddy surface, as shown in Fig. 1, the coefficient of traction is lower and travel reduction is higher than normal. The coefficient of traction, as used here, is the quotient of drawbar pull divided by the weight on the driving members; this weight, in the case of the track-type tractor, being the weight of the tractor itself.

Attention is called to curve 4A in Fig. 2, which shows the relation between travel reduction and the coefficient of traction of the Caterpillar "Thirty" tractor on official tractor test No. 272, University of Nebraska.

Those who are acquainted with traction conditions of the University of Nebraska tests will recognize that for this No. 272 test the track condition was about average for all track-type tractor tests that have been made. In this particular test, the observed drawbar pull in low gear was 7,211 pounds, or 72.4 per cent of the tractor weight, as tested with a slip of 5.39 per cent, and at rated governed engine speed. The amount of slip produced at lower drawbar pulls is indicated by the curve.

During the past summer this tractor was tested on the clay track at the Caterpillar proving grounds. This track is clay subsoil, almost void of humus. The clay particles are extremely fine, and they compact or cement together by the action of rain. When dry, the soil breaks down into fine dust under the action of the tractor lugs.

The curve 4B represents the performance of this tractor on the clay track when at the condition most favorable for traction. As indicated by the curve, for the clay surface, the slip is higher than on the Nebraska test track for the same drawbar pull.

The curve 4C is for the clay track when covered by dust to the depth of lug penetration. When the track was dusty, the tractor pulled 66 per cent of its weight when slipping 15 per cent, and this tractor engine had sufficient torque to slip the track more than 15 per cent. Other series of tests were made when the clay track was in intermediate stages. The results of these tests are a series of curves betwen 4B and 4C.

Having established the performance of the track-type tractor as shown by the curves, the performance of a rubber-tired auto patrol will now be presented.

The auto patrol tests shown are for the Caterpillar diesel No. 10 tandem-drive model (Fig. 3). The four driving rear wheels, each equipped with a 11:25x24 tire at 25 lb per sq in air pressure, turn as a unit, there being no differential action. The static load on the driving

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Author: Superintendent of proving grounds, Caterpillar Tractor Co. Mem. ASAE.

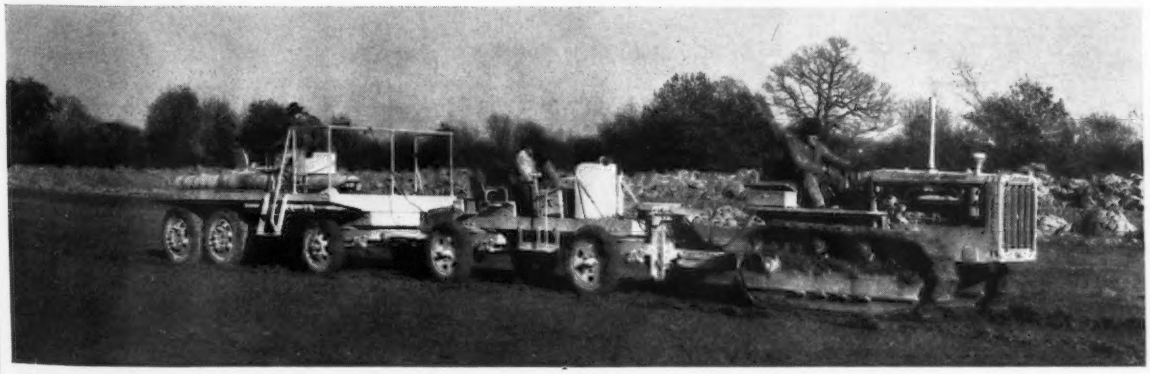


FIG. 1 DETERMINING THE COEFFICIENT OF TRACTION ON A MUDDY SURFACE

wheels was 12,090 lb, or 3,022 lb per tire. The auto patrol tests were made by hitching the dynamometer to the drawbar provided at the rear end.

Curves 10C and 10B are for the same soil surfaces as for curves 4C and 4B (Fig. 2).

The auto patrol had sufficient power to produce a higher travel reduction. A limit of 15 per cent is shown here.

Those who have a knowledge of the relation between travel reduction and drawbar pull are greatly concerned about the balance that produces the most work done at the least cost. Excessive travel reduction causes excessive tire wear, yet under many conditions a fairly high travel reduction is necessary to produce an acceptable coefficient of traction. This problem is not so serious with steel lugs, where travel reduction has a lesser influence on track than on tire life.

The curves 10G are for the auto patrol on scarified gravel and on a gravel road where the gravel averages ½ in and less in size and in a loose layer ¾ in deep. On these surfaces, a higher drawbar pull is attained with less travel reduction than on any of the clay subsoil. This result is of particular interest when balanced against the fact that the scarified surface was loose for a depth of approximately 10 in and the material was round rock in size up to 4 in in diameter.

The last curve to be mentioned is 10D, which is for rubber on dry, smooth, clean concrete. This curve presents, as its chief significance, a type of test that can be duplicated because of the permanency of the concrete surface and the availability of concrete roads in most parts of the country.

It is hoped that these data will serve as a challenge to agricultural engineers to establish a more universal practice of reporting machine performance more completely; to report the amount of travel reduction, particularly where it is so great that power losses or tire wear become excessive for practical application.

Before leaving this subject, it might be well to acknowledge the well-established fact that there are many factors involved in tractor design and application other than those mentioned here. These tests report only two major factors and their relation to each other. Time does not permit a discussion of any more of these factors.

The corollary to the application of rubber tires on

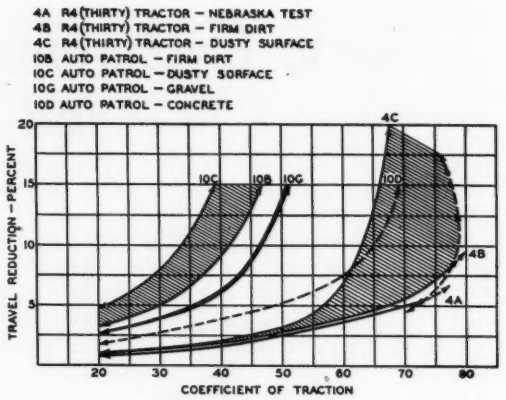


FIG. 2 THE RELATIONSHIP OF TWO FACTORS IN TRACTION

tractor wheels is their use on wagon wheels (Fig. 4). Even though the tests to be reported here are on dirt-hauling wagons of rubber and track wheel design, such as used on construction work, the duties of the wheels and surfaces encountered are similar to those for agriculture.

The results of tests and field observations show a striking direct correlation, under many conditions, between the coefficient of traction for the tractor-driving member and the draft or towing resistance per unit of weight of the loaded wagon or trailer. That is, a series of soil conditions can be set up to show, on one end of the series, a condition of maximum coefficiency of traction coupled with low towing resistance; and on the other end of the series, a condition of low coefficiency of traction coupled with a high towing resistance.

Other series of conditions can be set up to show opposite relationships.

Because these relationships are largely controlled by soils as to type, physical properties, and moisture, the picture is complicated, but not hopeless. A further classification of this situation is a worthy goal for the agricultural engineering profession.

Tractors and wagons equipped with rubber tires, as well as tracks, have been towed over various surfaces behind the drawbar dynamometer. For purposes of direct comparisons, towing resistance is expressed in pounds of

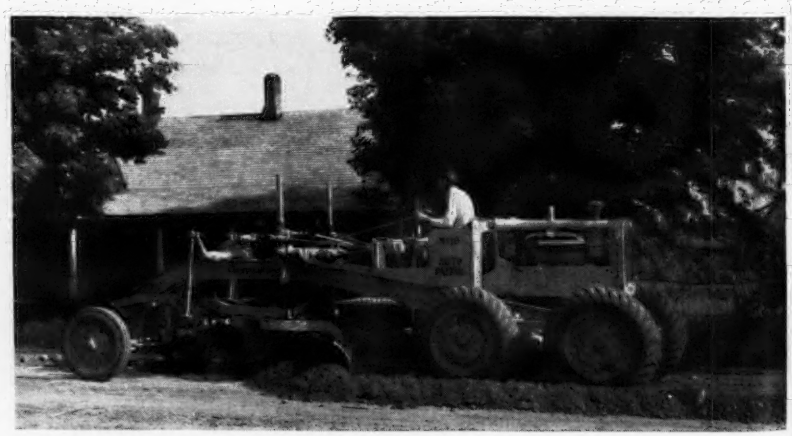


FIG. 3 FOUR-WHEEL-DRIVE MOTOR GRADER OF MODEL USED IN TRACTION TESTS

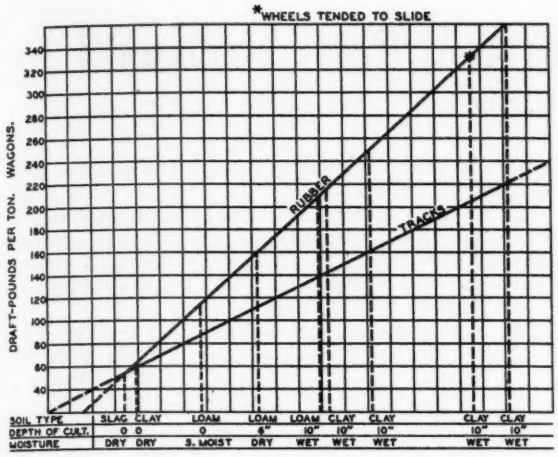


FIG. 5 DRAFT CHARACTERISTICS FOR CERTAIN WHEEL TYPES AND SOIL CONDITIONS

draft per ton of gross weight. Fig. 4 illustrates three wagon types and one scraper used in these tests.

In Fig. 5 the two curves are for dirt-hauling equipment. The track-type wagon is an Athey model E-32, 13-cu yd, two-way dump, equipped with two track wheels, gross loaded weight being 27.79 tons. The curve for rubber is the average for two wagons, each equipped with 18x24-in tires. The average gross load for each tire for the two wagons was 13,180 lb.

On hard-packed, smooth soil and slag surfaces, all of the wagons had approximately the same draft, 50 to 70 lb per ton. Under conditions of greater draft, caused by an increase of soil moisture or cultivation, or both, the draft of rubber increased more rapidly than did the draft of tracks. These curves are for a series of tests on two soil types, clay and light loam, and for a rather complete range of conditions from the standpoint of cultivation, compaction, and moisture. Other soil types may produce different curves.

One cannot be exposed to this type of testing for a period of time without making observations regarding equipment performance and soil reaction. The several factors of a given soil that affect wagon draft are sometimes expressed more strikingly on the dynamometer chart than visually. On one series of runs, it was noted that the draft varied as much as 20 per cent over a surface that apparently was absolutely uniform. A closer observation disclosed that even though the surface was stable and uniform, it was slightly deflected in spots under the wagon wheel, and this deflection was so slight that it was difficult to notice.

When pulling a loaded wheel over a surface, the least draft is obtained when the axle travels in a horizontal plane, and when there is no movement, or deflection, of the tire or of the soil surface. For a given wagon and load, the amount of soil deflection or displacement is a function of the unit pressure exerted by the wheel, and the amount of tire deflection is a function of tire design and inflation. There is no appreciable deflection of the track-type wheel.

Over a series of conditions, from dry to wet, the type of wagon that shows the greatest range in draft is the one which has the highest unit pressure on the soil surface. This theory was checked in another way—by pulling the wagons over the same track a number of times. The soil displacement under the wheels may be too slight for observation, but by multiplying the effect, deep ruts are made, where on the first time over only the dynamometer was sensitive enough to detect the difference in draft.

These curves show, for dry loam cultivated 6 in deep, the draft for tracks to be 116 lb per ton and the draft for rubber to be 160 lb per ton.

When designing a wagon or other implement for rubber tires, an exceedingly important point is the relation of the center of mass and wheel location. When traveling over an uneven surface, draft is materially greater for the wagon that tips sideways the most. Moreover, on a haul road the wagon may be required to travel in the same tracks repeatedly, and the maintenance is greatest for that design that causes most rutting.

In conclusion, let the challenge to agricultural engineers be repeated: to produce more available data on (1) the relation of tire wear to travel reduction and (2) the relation between coefficiency of traction and towing resistance. The answers to this challenge are the answers to a lot of questions by owners and users of tractors and tractor-hauled equipment.

FIG. 4 WHEEL AND FOOTING TYPES USED IN WAGON DRAFT TESTS

Rating Tractor Tires for Performance

By J. W. Shields

THE INCREASING popularity of tires on farm tractors has introduced many new problems for both the tractor manufacturers and the tire industry. One of the most important of these problems is that of establishing an adequate method of rating the tires according to the performance they are expected to deliver.

Truck tires are rated for the load they will support, without excessive deflection, at a specified air pressure. This is of course logical, as the chief function of these tires is that of carrying a load; traction is secondary. For tractor tires the reverse is true, as the most important work of these tires is providing traction for pulling, and the load carried is more or less incidental.

An analysis of the stresses in an average size rear tractor tire shows that when pulling a heavy load the stresses in the cords, due to the tractive effort, are more than twice those resulting from the inflation pressure and deflection. This is demonstrated in service by the fact that by far the most important type of failure found in rear tractor tires is that of "diagonal sidewall buckles". These buckles are caused by the tractive effort and not by the load or deflection resulting from load.

If we follow the present rating schedule it is possible and, in fact, quite common to have a tractor equipped with tires, which according to carrying capacity and inflation pressure are adequate, but which will fail prematurely because of the traction developed.

A set of tires operated in light sandy soil might give excellent service, but the same tires on the same tractor with the same inflation pressure and wheel weights might fail in a short time from sidewall buckles if operated in heavy soil where they would develop two to three times as much traction.

It is commonly recognized that sidewall buckling can be overcome by increasing the inflation pressure. It would therefore seem that the industry should develop a schedule of recommended inflation pressures based on a combination of load carried and drawbar pull.

In making this suggestion I recognize that the drawbar pull bears a direct relation to the load in a given soil, and also the fact that it will be impossible to determine farm operating conditions from day to day. There are, without doubt, many problems connected with developing such a program and putting it into practice, but it is believed that it would be well worth while for the industry to carefully consider the possibility of using some such method.

With the present method of rating tires by carrying capacity, it is difficult to determine the proper size for a tractor, as there is no tractor on the market that is heavy enough to load the proper tires to capacity without the addition of extra weight.

It is common for different engineers to choose tires of different sizes because they approach the problem from different angles. It would seem that we should, if possible, standardize on a method for determining the proper tire equipment which could be used by the entire industry, and I believe the tractor engineers would lend their individual support toward such a program.

Since the chief function of tractor tires is to provide traction for utilizing the power developed by the engine, it would seem that the engine horsepower, and not the tractor weight, should be used as the base for determining tire size.

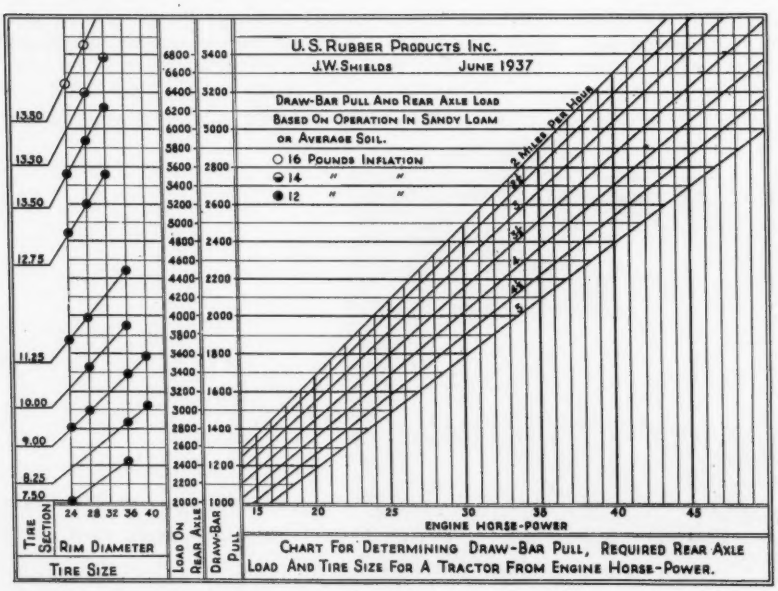
The tractor industry rates tractors roughly according to their pulling ability as one-plow, two-plow, and three-plow tractors. I have found it convenient and practical to rate tires in the same way, and I think of one tire as suitable for a one-plow tractor and another as a two-plow tire. This is a crude method, but crude as it is, it seems to work better than the load-rating method now standard in the industry.

In trying to arrive at some logical method to follow in choosing the proper tire equipment for tractors, I have formulated the following requirements:

1 The tires should provide traction to handle, without excessive slippage, the full power of the engine when it is operating in plow gear in average soil.

2 Average soil is considered as moist loam or other soil with a coefficient of traction of 0.5. For other than average soils, oversize or special tires should be used.

3 From the horsepower of the engine compute the expected drawbar pull in plow *(Continued on page 33)*



Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Illinois, November 30, 1937.

Author: Farm Tire Department, United States Rubber Products, Inc. Mem. ASAE.

Effect of Tire Size on Tractor Efficiency

By R. H. Wileman

WE ARE no longer confronted with the question as to whether low-pressure rubber tires have a place on farm equipment. The present problems consist mainly in finding the best ways and means of applying this type of tire to both farm tractors and implements.

Comparative studies of rubber tires with steel wheels for tractors were started by the Purdue University Agricultural Experiment Station in the spring of 1933. These studies have been continued each year since that time to determine the relative efficiency of these two types of wheel equipment under various field operating conditions.

In the tests we have conducted, no attempt has been made to determine the maximum drawbar pull of the tractor or to compare the pull at various tractor speeds with different wheel equipment. These tests were made during the performance of actual field operations under prevailing weather and soil conditions, as it was felt that tests of this kind would give results as nearly comparable to average farm operating conditions as possible. The tractor was operated, in all cases, at the available speed which was considered to give the best performance in handling the load placed behind it.

The immediate interest and resulting purchases of low-pressure tires by farmers led to the production of quite a choice of tire sizes for farm tractors. This resulted in there usually being a choice of two or three sizes of tire equipment available for new tractors, as well as for change-over applications for tractors which already were in use. This choice of tire sizes resulted in an increasing number of questions from farmers as to what size tires they should purchase for use on their tractors.

In order to answer these questions more intelligently, a series of tests comparing various sizes of tires on different size tractors were conducted. It should be understood that these tests were made on tractors whose speed was primarily set for use with steel wheels. The results presented, therefore, do not necessarily mean that a certain size tire is better adapted to this particular size of tractor except as it affects the rate of travel with the speeds which are available.

It is felt that in most cases difference in operating efficiency of two different sizes of tires and tire equipment is largely due to the resulting speed of the tractor which uses the motor power available most efficiently.

The fuel consumption tests were made on areas of from 2 to 2.5 acres. The fuel used in turning at the ends was included as a part of the test, care being taken to see that there was but little variation in the amount of dead-heading during the tests.

Tables 1 and 2 give the results secured with regular sizes of tire equipment on both the two and three-plow size tractor, while plowing in varying conditions.

The results shown in Tables 1 and 2 give comparisons of the efficiency of two and three-plow tractors under varying plowing conditions when equipped with steel wheels and two sizes of rubber tires.

The greater efficiency shown by the rubber tires over steel wheels can be largely accounted for by the reduction in rolling resistance of the tractor itself when equipped with rubber tires. In comparing the efficiency of the different sizes of rubber tires it will be found that the difference in the amount of fuel used is directly related to the rate of travel of the tractor.

It has been our experience that the tractor could be operated one gear faster by replacing the steel wheels with rubber tire equipment, unless the rolling radius of the rubber tires was enough greater to materially increase the speed in the same gear.

In using rubber tires which reduce the rolling radius as compared to the steel wheel equipment, a part of the advantage of the rubber tires can readily be lost.

To secure full advantage of the rubber tire equipment,

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Illinois, November 30, 1937.

Author: Agricultural engineer, Purdue University Agricultural Experiment Station. Mem. ASAE.

TABLE 1. TWO-PLOW TRACTOR PULLING TWO 16-IN BOTTOM PLOWS 8 IN DEEP

Type of wheels	Type of ground	Average drawbar horse-power	Average rolling resistance of tractor, hp	Engine load, drawbar hp plus rolling resistance	Speed, miles per hour	Fuel, gal per acre	Fuel per cent of steel	Fuel saving over steel, per cent
Steel	Wheat stubble	12.35	8.42	20.77	3.02	2.46	100.0	
Rubber 9.00x36-in	Wheat stubble	14.60	4.28	18.88	3.58	2.18	88.6	11.4
Steel	Alfalfa sod	13.47	6.25	19.72	3.66	3.04	100.0	
Rubber 9.00x36-in	Alfalfa sod	16.65	2.65	19.30	4.25	2.70	88.8	11.2
Rubber 11.25x28-in	Alfalfa sod	16.05	2.85	18.90	4.20	2.67	87.6	12.4

TABLE 2. THREE-PLOW TRACTOR PULLING THREE 14-IN BOTTOM PLOWS 7-IN DEEP

Type of wheels	Type of ground	Average drawbar horse-power	Average rolling resistance of tractor, hp	Engine load, drawbar hp plus rolling resistance	Speed, miles per hour	Fuel, gal per acre	Fuel per cent of steel	Fuel saving over steel, per cent
Steel	Corn stalk	15.02	8.40	23.43	3.48	2.60	100.0	
Rubber 11.25x24-in	Corn stalk	14.26	3.77	18.03	3.45	2.32	89.1	10.9
Rubber 11.25x28-in	Corn stalk	15.71	4.55	20.26	3.69	2.19	84.3	15.7
Steel	Wheat stubble	14.86	9.52	24.38	3.48	2.27	100.0	
Rubber 11.25x24-in	Wheat stubble	14.98	3.77	18.75	3.43	1.90	83.8	16.2
Rubber 11.25x28-in	Wheat stubble	16.00	4.54	20.54	3.74	1.71	75.4	24.6
Steel	Alfalfa sod	16.12	10.08	26.20	3.54	2.72	100.0	
Rubber 11.25x28-in	Alfalfa sod	19.40	4.12	23.52	3.97	2.36	86.7	13.3

TABLE 3. SEEDBED PREPARATION WITH TWO-PLOW TRACTOR PULLING 8-FT TANDEM DISK AND 10-FT SPIKETOOTH HARROW

Type of wheels	Type of ground	Average drawbar horse-power	Average rolling resistance of tractor, hp	Engine load, drawbar hp plus rolling resistance	Speed, miles per hour	Fuel, gal per acre	Fuel per cent of steel	Fuel saving over steel, per cent
			First time over					
Steel	Alfalfa sod	11.30	6.18	17.48	3.21	1.02	100.0	
Rubber 9.00x36in	Alfalfa sod	12.98	5.11	18.09	4.17	0.85	83.3	16.7
Rubber 11.25x28-in	Alfalfa sod	11.88	5.62	17.50	3.96	0.87	85.3	14.7
			Second time over					
Steel	Alfalfa sod	12.30	5.51	17.81	3.55	1.05	100.0	
Rubber 9.00x36-in	Alfalfa sod	12.62	5.04	17.66	4.46	0.91	86.6	13.4
Rubber 11.25x28-in	Alfalfa sod	11.93	5.62	17.55	4.17	0.86	82.2	17.8

the size of tires used must be large enough so that by increasing the axle speed one gear through the transmission, the ground speed is increased sufficiently to utilize the extra drawbar horsepower made available by the reduced rolling resistance of the tractor when equipped with rubber tires. This point is important because there is usually only one field speed above that normally used with steel wheels.

This naturally raises the question: Why not increase the load behind the tractor rather than the speed of travel when rubber tires are used? It has been our experience and, I believe, the experience of others who have tested rubber tires, that more satisfactory operation and greater efficiency can be secured by increasing the speed of the tractor rather than the load behind it, when changing from steel to rubber tires.

This fact makes it important that tires of the proper size be selected to suit the available speeds of the tractor in order to secure the best operating efficiency.

The results of similar tests made during seedbed preparation are shown in Tables 3 and 4. These data give the results secured for both the first and second times over the field after plowing. An 8-ft tandem disk and a 10-ft spiketooth harrow were the tools used for the seedbed preparation.

These data show the difference in rolling resistance between steel wheels and rubber tires to be less when working on plowed ground than when plowing. This might be expected, however, as in plowed ground the wheels sink into the loose soil and, in effect, are continually climbing up grade.

These data show but little difference in the rolling resistance between the steel wheels and rubber tires in the case of the lighter tractors when working on plowed ground. This might be misleading unless it is remembered that the tractor speed was faster when equipped with rubber tires; thus the actual pounds of pull was considerably less.

I also wish to point out that the actual drawbar horsepower developed was practically the same for the steel as for the rubber, although the speed was increased in most cases when the rubber tires were used. In trying to determine a reason for this it was found that although the height of the drawbar was kept the same, the depth to which the disk penetrated decreased as the speed increased. The result of an increase in speed without changing the angle of the disk was that better pulverization of the soil resulted, although it did not extend quite as deep as when the speed was reduced.

The differences in the amount of fuel used show a direct relationship to the speeds of operation of the tractor when equipped with steel wheels and rubber tires. It will be noted that there are some variations between the two sizes of rubber tires which are rather hard to explain. These differences can probably be best accounted for by slight variations in the loose soil conditions which affect the draft of the implement and the wheel slippage.

A greater difference between the rolling resistance of the steel wheels and rubber tires was found with the three-plow than with the two-plow tractors on plowed ground. The difference in weight of the two sizes of tractors which caused the heavier tractor to penetrate deeper into the loose soil is probably the best explanation for this variation. This was very apparent in the plowed alfalfa sod where the soil pulverized more and was much looser than was the case with the timothy sod.

It is apparent from these data that it is important to select a size of rubber tire which has the proper overall diameter to fully utilize the advantages of the reduced rolling resistance of the tractor, in order to secure the best operating efficiency.

TABLE 4. SEEDBED PREPARATION WITH THREE-PLOW-TRACTOR PULLING 8-FT TANDEM DISK AND 10-FT SPIKETOOTH HARROW

Type of wheels	Type of ground	Average drawbar horse-power	Average rolling resistance of tractor, hp	Engine load, drawbar hp plus rolling resistance	Speed, miles per hour	Fuel, gal per acre	Fuel per cent of steel	Fuel saving over steel, per cent
			First time over					
Steel	Timothy sod	13.32	7.55	20.87	3.15	0.88	100.0	
Rubber 11.25x24 in	Timothy sod	13.99	4.07	18.06	3.21	0.82	93.4	6.6
Steel	Alfalfa sod	12.50	12.10	24.60	3.98	0.95	100.0	
Rubber 11.25x28-in	Alfalfa sod	11.30	9.22	20.52	4.07	0.85	89.5	10.5
			Second time over					
Steel	Timothy sod	11.78	7.16	18.94	2.89	1.06	100.0	
Rubber 11.25x24-in	Timothy sod	13.65	3.68	17.03	3.15	0.89	84.1	15.9
Steel	Alfalfa sod	13.00	11.34	24.34	4.19	1.00	100.0	
Rubber 11.25x28-in	Alfalfa sod	11.66	8.18	19.84	4.05	0.90	90.0	10.0

Tests of Tillage Tools

II. Effects of Several Factors on the Reactions of Fourteen-Inch Moldboard Plows

By John W. Randolph and I. F. Reed

FREQUENTLY the question is asked, "What is the average draft of a moldboard plow in different soil types?" Although the plow is one of our oldest power tillage tools in common agricultural usage and there are a vast number of published records of plow studies and draft measurements, a correct answer would require the results from a more exhaustive series of tests than all these data combined. A study of these records shows little correlation in the data obtained by different workers, due in part at least to the fact that in most of these studies the soil has been treated as a constant. Very few measurements indicative of the conditions of the soil were made, and if any consideration was given to the type or condition of the soil, it was only in casual statements accompanying the data. On the other hand, elaborate measurements have been recorded of the use, condition, setting, and type of plow.

The soil in any tillage study must be treated as a dynamic material if the tests are intended for correlation studies. This is true because the resistance of the soil to the action of a tillage tool is constantly changing, as a result of the effects of heat, light, water, bacterial and chemical action, and plant life, all modified in turn by time. The tillage record of the test area must also be taken into account, as soils become stratified and are physically altered by the depth and character of the previous tillage, and by their translocation by water and wind. These things influence the reaction of a tillage tool differently in various ranges of depth in operation.

Fig. 1 shows the average draft per square inch of furrow slice cross section of a 14-in general-purpose moldboard plow in several representative soil types of the Southeast. The test points indicated for each soil were obtained in a reasonably short period, upon an area that to the eye was uniform and typical. The results show a wide variance from a mean curve. The fluctuation of the plow draft over a considerable distance of furrow may be considered as caused by variations in the mechanical and physical condition of the soil and the unavoidable errors in test procedure. The accurate measurement of the depth of plow operations in the tests shown was difficult because the land had been in cultivated row crops. The surface was somewhat ridged and the soil varied in density and moisture in the row and middle.

Fig. 1 indicates that the variation in soil properties given in Table 1 has some correlation to plow draft. The tendency for certain soils to be stratified into surface and subsurface layers causes marked changes with changes in depth.

Fig. 2 shows results of a more detailed plow-draft study on Red Bay fine sandy loam. The points indicated are the average values for turning both rows and middles of 1/12-acre plots under more controlled field conditions. Even though every effort was made to plow at a uniform

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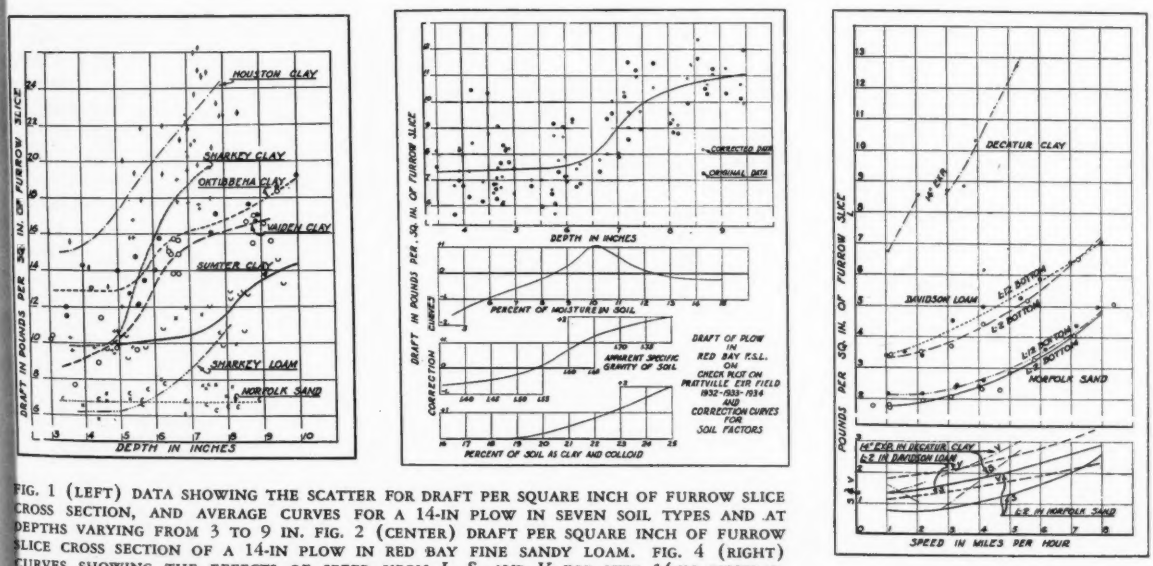
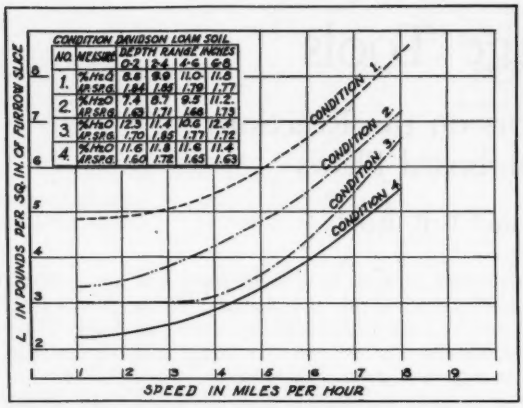

HOUSTON CLAY
SHARKEY CLAY
OKTIBBEHA CLAY
WAIDEN CLAY
SUMTER CLAY
SHARKEY LOAM
NORFOLK SAND
DRAFT IN POUNDS PER SQ. IN. OF FURROW SLICE
DEPTH IN INCHES
DRAFT IN POUNDS PER SQ. IN. OF FURROW SLICE
CORRECTED DATA
ORIGINAL DATA
DEPTH IN INCHES
PERCENT OF MOISTURE IN SOIL
CORRECTION CURVES
APPARENT SPECIFIC GRAVITY OF SOIL
DRAFT OF PLOW IN RED BAY F.S.L. ON CHECK PLOT ON PRATTVILLE EXP. FIELD 1932-1933-1934 AND CORRECTION CURVES FOR SOIL FACTORS
PERCENT OF SOIL AS CLAY AND COLLOID
DECATUR CLAY
DAVIDSON LOAM
NORFOLK SAND
POUNDS PER SQ. IN. OF FURROW SLICE
SPEED IN MILES PER HOUR

FIG. 1 (LEFT) DATA SHOWING THE SCATTER FOR DRAFT PER SQUARE INCH OF FURROW SLICE CROSS SECTION, AND AVERAGE CURVES FOR A 14-IN PLOW IN SEVEN SOIL TYPES AND AT DEPTHS VARYING FROM 3 TO 9 IN. FIG. 2 (CENTER) DRAFT PER SQUARE INCH OF FURROW SLICE CROSS SECTION OF A 14-IN PLOW IN RED BAY FINE SANDY LOAM. FIG. 4 (RIGHT) CURVES SHOWING THE EFFECTS OF SPEED UPON L, S, AND V FOR TWO 14-IN GENERAL-PURPOSE BOTTOMS IN TWO SOIL TYPES, AND A STUBBLE TYPE BOTTOM IN A HEAVIER SOIL


CONDITION DAVIDSON LOAM SOIL
NO. MEASURE DEPTH RANGE INCHES
0-2 2-4 4-6 6-8
1. %H2O 8.6 9.9 11.0 11.8
APSPG 1.84 1.85 1.78 1.77
2. %H2O 7.4 8.7 9.8 11.2
APSPG 1.83 1.71 1.68 1.73
3. %H2O 12.3 11.4 10.6 12.4
APSPG 1.70 1.85 1.77 1.72
4. %H2O 11.6 11.8 11.6 11.4
APSPG 1.60 1.72 1.65 1.63
CONDITION 1
CONDITION 2
CONDITION 3
CONDITION 4
L IN POUNDS PER SQ. IN. OF FURROW SLICE
SPEED IN MILES PER HOUR

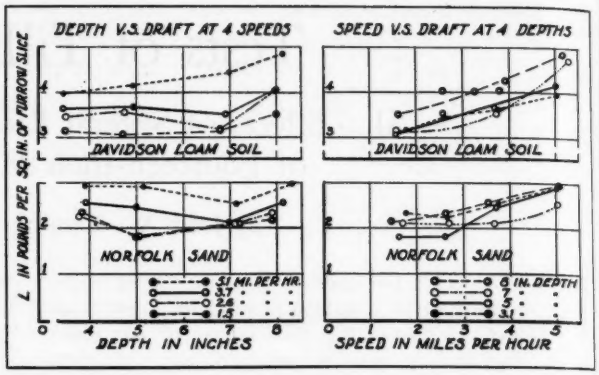


FIG. 3 (LEFT) CURVES SHOW THE EFFECT OF CHANGES IN MOISTURE CONTENT AND APPARENT SPECIFIC GRAVITY ON THE VALUES OF L FOR A 14-IN GENERAL-PURPOSE BOTTOM IN DAVIDSON LOAM SOIL. FIG. 6 (RIGHT) CURVES SHOWING THE VARIATIONS IN L FOR A 14-IN GENERAL-PURPOSE BOTTOM IN TWO SOIL TYPES WITH CHANGES IN BOTH DEPTH AND SPEED

depth, there were marked variations, and it was almost impossible to make the plow run level. The data given cover a period of three years. The results, as in Fig. 1, show a wide distribution of values from a mean curve. Correcting the plow draft data, with reference to the soil's apparent specific gravity, its percentage of moisture at the time of plowing, and the percentage of clay and colloid as it varied from plot to plot, does not completely eliminate the variation from a mean curve. The correlation curves indicate the probable effect upon draft as caused by differences of the factors given. It may be that other soil measurements or methods of sampling, bearing a definite relationship to the working forces, will give closer correlation of field data. So far no single index has been found which permits direct intercorrelation of tillage studies upon different soil types or conditions.

Though the field data shown in Figs. 1 and 2 were obtained as carefully as possible and observations indicated that soil conditions were quite uniform over the test areas, the variations in draft about the mean are greater than would be produced by variations in plow design or normal operation in a uniform soil.

The Farm Tillage Machinery Laboratory described in an earlier article[1] is equipped to reduce many of the variables encountered in field work. Equipment available permits measurement of the effects of tillage tool design and operation on the force reactions of the tool as it is held accurately in a frame operating on the rails carrying the test equipment. The soil for test is in a very nearly uniform condition.

In the plow tests the plow bottom is mounted upon a beam supported entirely on hydraulic units[2] with recorders for making continuous charts of each test furrow. This equipment is designed to allow mounting all bottoms according to the specifications furnished by the manufacturer. The hitch on the front of the beam is made as for hitching to a tractor in the field, so that it is possible to determine the pull, the side draft, and the vertical loads.

Symbols used and adjustments and factors constant for laboratory tests:

L = Directional component of forces on the plow bottom. Since the forces required for handling the coulter and plow frame are not included in any of these tests, L is equal to the directional component of the pulling force or draft but is opposite in direction.

Draft = The directional pulling froce. It includes load of plow frame and coulter for field tests.

V = Vertical component of forces acting on plow bottom.

S = Side component of forces acting on plow bottom.

The coulter was mounted on a frame independent of the beam and was set just wide enough to allow the shin to clear the furrow wall for all tests. It was set 3½ in deep for all tests except those for determining the effect of depth of cut. For the latter it was set at a maximum of 4 in deep for the deep plowing and was adjusted to two-thirds the plowing depth for depths shallower than 6 in.

All tests, except those for determining effect of landside, were made with landside and as much as possible of

[1]Randolph, J. W. and Reed, I. F. The Farm Tillage Machinery Laboratory. Agricultural Engineering, Vol. 16, No. 6, June 1935.

[2]Reed, I. F. Tests of Tillage Tools—I. Equipment and Procedure for Moldboard Plows. Agricultural Engineering, Vol. 18, No. 3. March 1937.

TABLE 1. ANALYSIS AND CONDITION OF SOILS USED IN FIELD PLOW DRAFT TESTS

	Soil fractions in per cent								Atterberg's plasticity constants				
Soil type	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Colloid	Lower limit	Upper limit	Number	Apparent specific gravity	Moisture, per cent
Norfolk sand	0.00	0.00	8.10	46.00	20.30	15.00	2.6	8.0	Not plastic			1.64	6.00
Red Bay fine sandy loam	1.57	15.51	21.64	22.14	5.91	14.22	3.46	15.52	Not plastic				
Viaden clay	0.33	1.02	3.09	3.62	5.25	27.64	11.85	47.2	26.17	44.35	18.18	1.21	29.0
Sumpter clay	0.54	0.95	1.04	4.65	3.92	42.60	4.00	42.30				1.25	22.8
Oktibbeha clay	0.15	0.61	0.91	3.14	1.48	38.13	9.78	45.80	25.37	43.08	17.71	1.11	27.9
Huston clay	0.59	0.30	0.40	1.31	13.57	29.43	4.80	49.60	21.00	36.40	15.40	1.18	31.6
Sharkey clay								59.00	24.86	36.53	11.67	1.33	19.6
Sharkey loam									Not plastic			1.36	19.6

the landside of share removed. The hitch setting on the front of the beam was constant for all tests. This point was kept 22 in above the bottom of the furrow and directly in front of the shin.

The soil conditions were as shown for each series of tests. Only tests in which the soil conditions were nearly the same were compared unless the soil variable was being considered. This discussion is limited for the most part to the two soils, Norfolk sand and Davidson loam. The values for Decatur clay are given to show the range that would be encountered with heavier soils.

TABLE 2. CONDITION OF SOILS FOR TESTS ON EFFECT OF SPEED ON DRAFT (Fig. 4.)

Range of depth sample	Per cent of moisture				Apparent specific gravity			
	0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in	0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in
Bottom				NORFOLK SAND				
L12	4.8	5.5	7.0	8.0	1.69	1.66	1.70	1.69
L2	4.8	5.5	6.3	7.0	1.67	1.67	1.69	1.68
				DAVIDSON LOAM				
L12	7.9	8.6	9.4	11.2	1.59	1.62	1.70	1.79
L2	7.4	8.7	9.5	11.2	1.63	1.71	1.68	1.73
				DECATUR CLAY				
14-in EXP.	17.2	19.0	19.7	21.5	1.56	1.66	1.56	1.56

Values of L, S, V and draft are stated in pounds per square inch of furrow slice cross section.

Plow Bottoms Used. This discussion is limited to 14-in bottoms except for discussion of the effect of width of cut. No data on width of cut were available for a 14-in bottom so data for 12-in and 16-in bottoms are used.

L2 = A 14-in general-purpose tractor plow bottom with soft center steel share and mold

L12 = A 14-in general-purpose bottom similar to L2 but of another make.

14 EXP = A 14-in stubble bottom with shin built up to clean landside. Used only for Decatur clay soil.

L1 and L3 = 12 and 16-in general-purpose bottoms, respectively. They have soft center share and moldboards and are made to conform to the same shape templates as for L2 above.

The cutting edges of the shares for all bottoms were used as received from the manufacturer. They show but little wear to date.

This paper will discuss the effects of soil condition, speed, depth and width of cut, and landside on the L, V, and S components of the plow bottoms listed above.

Effect of Soil Condition. Fig. 3 shows that changes in either the compactness of the soil as measured by apparent specific gravity, or the percentage of moisture, affect the force reactions of the Davidson loam soil markedly. Curves for conditions 2 and 4 show the effect of a change of approximately 2.5 in the percentage of moisture in the 2 to 6-in range as the apparent specific gravity was approximately the same for both conditions. These curves indicate that this soil reaches a lubrication phase at slightly above 11 per cent. Likewise the curves for conditions 1 and 2 show the effect of changing the apparent specific gravity about 0.15 in the 0 to 6-in range with the moisture approximately constant.

The curve for condition 3 flattens off for speeds below 3 mph due to a tendency toward non-shedding. These curves show definitely that soil conditions affect the force reactions for plowing and that until comprehensive correction curves to compensate for variation in moisture, apparent specific gravity, and other factors in the physical condition of the soil be available, it will be necessary to compare the effects of plow design and operation factors only for similar soil conditions. The variations in these curves help to explain the scatter of the points in Figs. 1 and 2. Though the data for Fig. 2 were corrected as far as possible for effects of compactness and moisture content, the interrelationships of these and other soil factors are not known; therefore only partial corrections could be made.

Effect of Speed. Studies made heretofore to determine the effect of speed on the draft of plows have for the most part been limited to speeds below 6 mph. It was noted that the draft, per square inch of furrow slice turned, increased with speed, but due to the limited speed range it was not possible to tell whether or not it was a straight line ratio. Ashby, Reed, and Glaves state in a mimeographed Progress Report on Draft of Plows Used in Corn Borer Control (1932), that the data obtained when using a cable plowing outfit for speeds of 1 to 6 mph might be better fitted by a parabolic form of curve than by a straight line, but all other tests were at lower speed so straight lines were drawn for all data.

The data for two 14-in general-purpose bottoms in Norfolk sand and Davidson loam, and one stubble type bottom in Decatur clay, are shown in Fig. 4. The moisture and apparent specific gravity for each of the soils for the tests on each bottom are shown in Table 2. These data show definitely that the increase in L or draft with speed is not a straight-line relationship. Parabolic curves of best fit have been fitted to the data for the Norfolk and Davidson soils by the method of least squares. It is to be noted that the actual test data deviate but slightly from the calculated curves, not only for the data shown in Fig. 4, but also in other figures used in this discussion. The curve for the data on the Decatur clay was not fitted by this method.

Parabolic curves of the standard form $y = a + bx + cx^2$ fitted to the test data have the following significance. The constant a, the y intercept, is theoretically the force required to handle the furrow slice at zero speed, b is the slope of the tangent at the intercept, and c is the constant for acceleration. The constant b becomes minus when nonshedding or excessive friction becomes active at low speeds as draft increases and the vertex of the parabolic curve is to the right of the axis. By transferring the axis from zero to any other speed, b becomes the slope of the tangent at that speed and is a measure of the relative rates at which L is increasing with increasing speeds.

The following are the formulas for the parabolic curves for bottoms L2 and L12 in Fig. 4, fitted by the method of least squares:

Formula for directional components: $y = L$; $x =$ speed.

Bottom	Soil	Formula as drawn in Fig. 4 with axis at zero speed	Formula with axis transposed to 3 mph
L12	Davidson loam	$y = 2.92 + 0.36x + .02x^2$	$y = 4.18 + 0.48x' + 0.02x'^2$
L2	Davidson loam	$y = 3.25 + 0.062x^2$	$y = 3.81 + 0.372x' + 0.062x'^2$
L12	Norfolk sand	$y = 2.18 - 0.134x + .0584x^2$	$y = 2.31 + 0.216x' + 0.0584x'^2$
L2	Norfolk sand	$y = 1.78 - 0.077x + .056x^2$	$y = 2.05 + 0.259x' + 0.056x'^2$

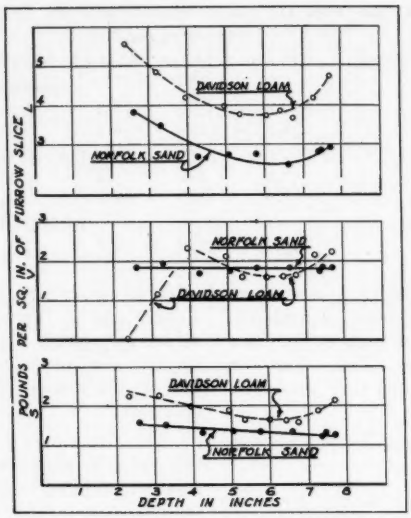
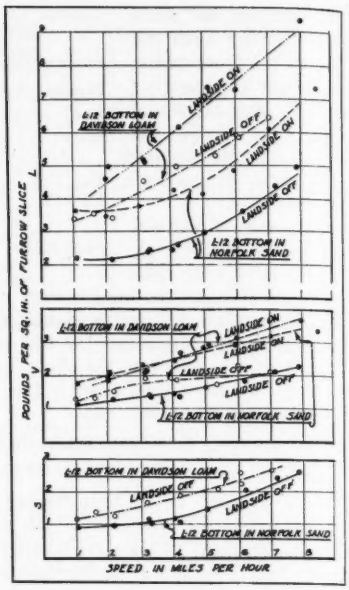


FIG. 5 (RIGHT) CURVES SHOWING THE VARIATION OF L, S, AND V WITH DEPTH OF PLOWING FOR A 14-IN GENERAL-PURPOSE BOTTOM. FIG. 7 (EXTREME RIGHT) CURVES SHOWING THE EFFECT OF THE LANDSIDE ON L, S, AND V FOR A 14-IN GENERAL-PURPOSE BOTTOM IN TWO SOIL TYPES. SIDE FORCES WERE NOT MEASURED FOR TESTS WITH THE LANDSIDE ON


L12 BOTTOM IN DAVIDSON LOAM
LANDSIDE ON
LANDSIDE OFF
LANDSIDE ON
LANDSIDE OFF
L12 BOTTOM IN NORFOLK SAND
L12 BOTTOM IN DAVIDSON LOAM
L12 BOTTOM IN NORFOLK SAND
L12 BOTTOM IN DAVIDSON LOAM
L12 BOTTOM IN NORFOLK SAND
POUNDS PER SQ. IN. OF FURROW SLICE
SPEED IN MILES PER HOUR

The S and V reactions follow the same laws in the field of normal plow operation and their data can be fitted by the same method. Often, however, the value of C is near zero and a straight line may be used.

Bottom	Soil	Side component with axis at zero speed $y = s$ $x =$ speed	Vertical component with axis at zero speed $y = V$ $x =$ speed
L2	Davidson loam	$y = 1.04 + 0.097x + .00867x^2$	$y = 1.73 + 0.047x + 0.022x^2$
L2	Norfolk sand	$y = 0.8140 - 0.1056x + .0405x^2$	$y = 1.25 + 0.089x + 0.015x^2$
L12	Davidson loam	$y = 1.631 + 0.1358x + .0134x^2$	$y = 1.15 + 0.162x - 0.000235x^2$
L12	Norfolk sand	$y = 0.8664 - 0.0254x + .0299x^2$	$y = 1.203 - 0.0062x + 0.0177x^2$

The curves for the vertical and side forces for the L12 bottom are shown in Fig. 7.

These curves and formulas show that L was higher for bottom L12 in both soils than for L2 bottom for speed up to 7 mph but that the rate of increase in L with speed was greater for bottom L2 at high speed. They show also that for the most part the rate of increase in L with increases in speed was relatively small for speeds below 3½ to 4 mph. This is the speed at which the throw of the furrow slice began to be excessive.

The results for the 14-in EXP bottom in Decatur clay do not give a consistent continuous curve as was found for the bottoms used in other soils. There is a break in the curve between 2 and 3 mph and the L component for the speed of 7.8 mph is low compared to the data for speed from 3 to 5.3 mph. Though the data is given here, further tests are needed in the heavier soils to definitely establish these relationships. It was noted, however, that the bottom did not shed for speeds below 3 mph. The break between 5.3 and 7.8 mph may be due to the fact that the furrow slice does not have time to break down to the moldboard surface at high speeds. Similar breaks have been found at critical speeds in studies of pontoons for planes.

The tests for the effect of speed on the reactions of 14-in general-purpose bottoms show that within certain ranges of speeds and soil conditions the rates of increase in L, S and V are a parabolic function of the speed. Note also the shapes of the curves for L plotted against speed in Fig. 6 and all curves in Fig. 7.

Effect of Depth. Results of tests in Norfolk sand and Davidson loam, shown in Figs. 5 and 6, indicate that 14-in general-purpose bottoms are designed to operate most effectually when cutting approximately 6 in deep. Preliminary studies on other sizes of bottoms indicate that their most efficient plowing depth is 5 to 7 in also, rather than one-half the width of cut, as has often been advocated. The soil conditions for the tests shown in Figs. 5 and 6 are given in Table 3. Note that the soil was very uniform throughout the depth of plowing. This condition is not often found in the field due to stratification of the soil; thus these tests show quite accurately the effect of depth, whereas most field tests of depth are modified by changing soil conditions.

The S and V reactions per square inch of furrow slice are almost constant throughout the range tried in the Norfolk sand, except that the S reactions were slightly higher for depths less than 4 in. The curves for the S and V reactions in the Davidson loam are approximately the same shape as the curves for the L reactions for the 5 to 7.7-in depth range, but due to a very slight crust formation the V reactions increase rapidly for 4 to 5-in depth. The plow bottom then tends to ride or scrape on the crust, causing V to drop off markedly for the 3.15-in depth and to become zero at the 2.45-in depth. This indicates that the weight of the plow was required to hold the bottom at uniform depth for this shallow cut. The curves for the L component of the forces acting on the bottom show that, since the forces required to shear the soil loose remain practically constant for all depths, L, in pounds per square inch

TABLE 3. SOIL CONDITIONS FOR TESTS ON EFFECT OF DEPTH OF CUT (Figs. 5 and 6.)

Range of depth of sample	Per cent of moisture 0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in	8 to 10 in	Apparent specific gravity 0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in	8 to 10 in
Soil					For Fig. 5					
Norfolk sand	5.0	5.8	6.9	7.7	8.8	1.69	1.75	1.70	1.71	1.66
Davidson loam	8.3	9.7	10.6	11.6	12.6	1.74	1.75	1.74	1.76	1.70
					For Fig. 6					
Norfolk sand	7.6	7.5	7.5	8.0	8.5	1.63	1.69	1.69	1.61	1.60
Davidson loam	9.1	8.9	8.7	10.9	11.7	1.73	1.66	1.59	1.62	1.57

TABLE 4. EFFECT OF WIDTH OF CUT ON THE FORCE REACTIONS FOR TWO SIZES OF BOTTOMS IN NORFOLK SAND

Width of cut, in	Bottom L, 1 to 12 in			Bottom L, 3 to 16 in		
	L	Vertical force, *V*	Side force, *S*	*L*	Vertical force, *V*	Side force, *S*
8	2.03	1.60	0.82	2.42	1.72	0.83
9	2.09	1.60	0.85			
10	2.12	1.61	0.75	2.49	1.70	0.86
11	2.16	1.55	0.90			
12	2.14	1.67	0.94	2.34	1.67	0.94
13	1.96	1.47	0.93			
14	2.10	1.56	0.93	2.42	1.55	0.93
15	2.08	1.60	0.98	2.31	1.43	1.12
16	2.16	1.60	1.07	2.31	1.50	1.13
18				2.35	1.53	1.24
20				2.49	1.48	1.33

(Note: Measurement of soil conditions show that the soil was drier for the tests on the 16-in bottom.)

of furrow slice; increases as the area of the slice decreases, which explains the increase in *L* for shallow depths. However, *L* also increases for depths greater than 6½ or 7 in. Observations of a number of bottoms operating at excessive depth indicate that at least a part of this increase is due to choking of the thick furrow slice in the curvature of the mold. The thick slice resists breaking down to the shape of the mold surface and tends to act as a resisting column. This is indicated in the curves in Fig. 6. The furrow slice breaks down to the mold nicely at the lower speeds and the lowest value for *L* is obtained at depths between 6 and 7 in, but shows no break at this depth for the 5-mph curve for Davidson loam. This indicates that the factor of depth of operation must be given careful consideration, especially in the design of speed bottoms.

Effect of Width of Cut. Table 4 shows the only results available at this time on the effect of the width of furrow cut by a bottom. They apply only to Norfolk sand and 12 and 16-in bottoms. These data show a maximum variation for *L* of 0.2 lb per sq in of furrow slice cross section and for *V* of 0.3 lb for either bottom, with the width of cut varied from 8 to 16 in for the 12-in bottom, and from 8 to 20 in for the 16-in bottom. Since there is no definite trend it may be assumed that the width a bottom is cutting has very little effect upon *L* for this soil condition. The values of *S* tend to increase with increasing width, especially at the widths above the rated width of cut for the bottom, due in part at least to the force required to shear over the uncut portion of the furrow slice. The reactions of the coulter, the resistance of the landside, or the draft of the plow frame are not included. Only the effects of the soil reactions on the plow mold and cutting edge are shown. The reactions of the coulter would be constant and the resistance of the landside and draft of the plow frame would change but slightly with different widths of cut. These factors would increase the unit draft for the narrow cuts markedly.

Effects of Landside. Landside friction affects the draft of a plow markedly, as may be seen by comparing *L* reactions for a bottom in two soils, shown in Fig. 7. These data show that not only is *L* higher due to the landside friction, but the rate of increase in draft with speed is greater for the bottom with the landside attached, owing to the greater amount of friction caused by the higher side pressures at the higher speeds. The increase in draft varied from 1 lb per sq in of furrow slice cross section at 3 mph to 2 lb at 7 mph for the Davidson loam and from 1.5 to 1.9 lb for the same speed range in the Norfolk sand. An efficient rolling landside or rear wheel can reduce this part of the draft markedly.

TABLE 5. SOIL CONDITIONS FOR TESTS ON EFFECTS OF LANDSIDE (Fig. 7.)

Range of depths of sample		Per cent of moisture				Apparent specific gravity			
Soil	Landside	0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in	0 to 2 in	2 to 4 in	4 to 6 in	6 to 8 in
Norfolk sand	On	4.3	5.3	6.3	7.9	1.61	1.67	1.63	1.63
	Off	4.8	5.5	7.0	8.0	1.69	1.66	1.70	1.69
Davidson loam	On	9.6	9.6	9.8	10.4	1.60	1.58	1.65	1.66
	Off	7.9	8.6	9.4	11.2	1.59	1.62	1.70	1.79

Rating Tractor Tires for Performance

(Continued from page 26)

gear, making allowance for losses due to gears and rolling resistance.

4 Provide sufficient weight on the tires to give the desired drawbar pull.

5 Choose a tire with carrying capacity for the required load.

In order to make it simpler, this has been developed into the accompanying chart which can be used to determine the proper tire size from the engine horsepower.

To choose tire equipment by means of this chart, start with the engine horsepower of the tractor as listed along the bottom of the chart. Follow vertically to the diagonal line representing the speed in plow gear. From this point of intersection move to the left horizontally. The first column of figures gives the drawbar pull the engine can develop in plow gear, making allowance for rolling resistance, etc. The second column of figures shows the weight which must be carried by the rear tires to handle this drawbar pull in average soil. Following on to the left is a chart representing the tractive ability of the various sizes of tractor tires grouped both by section diameter and by rim diameter. All tires falling below the projected horizontal line are too small and those that are above are adequate to handle the full power of the engine when operating in plow gear and in average soils.

The inflation pressures shown in this chart are based only on the industry load rating and do not take into consideration the drawbar pull as such data is not at present available.

It is fully recognized that this chart does not answer all questions in connection with the application of tractor tires and must be used along with good judgment. It is offered as a means of helping to solve the problem of providing a standardized method of choosing tire equipment.

S. H. McCrory First John Deere Medalist

FIRST award of the John Deere gold medal may be said to symbolize the coming of age of agricultural engineering in the eyes of the people and government of America. First to receive this signal honor is the first head of the first federal agency to be christened by the phrase "agricultural engineering," the same man who a decade later again was first chief when agricultural engineering attained its majority by becoming a bureau in the Department of Agriculture. That man is a past-president of this Society, Samuel Henry McCrory.

S. H. McCRORY

The professional career of Mr. McCrory is almost a perfect parallel of agricultural engineering as an organized profession. Born at Iowa City, Iowa, in 1879, he took his bachelor's degree in civil engineering from the state university in the same city, and immediately entered private practice at Sioux City, also in Iowa, specializing in farm drainage. That was in 1904. It was late in 1906, during the Christmas recess of the academic year, when occurred the first organizational meeting of the ASAE. In a matter of days, on January 1, 1907, Mr. McCrory entered the U. S. Department of Agriculture as drainage engineer in the Office of Experiment Stations. In 1912 he became engineer in charge of the work, and a year later chief of drainage investigations.

From a fragmentary arrangement of the components of agricultural engineering among several bureaus evolved the Division of Agricultural Engineering in 1921, with Mr. McCrory as its chief. Ten years later, after persistent representations by many members of the ASAE, it was raised to its present rank of bureau. Again the chief named was S. H. McCrory, and he continues in that position. Meanwhile he had won from his alma mater the degree of Civil Engineer in 1908, and in 1926 Iowa State College conferred on him the title of Agricultural Engineer.

In the words of the chairman of the Jury of Awards, Mr. McCrory's selection as the first John Deere medalist is in "recognition of the high value to agriculture and to society of the thirty years devoted to research and research administration in the U. S. Department of Agriculture." In so long and so varied a career, no single nor several achievements can be named as basis for the award, and any such attempt becomes more difficult as the increasingly administrative nature of his work has brought under his guidance a great diversity of activity. Among the landmarks along the way may be mentioned:

Development of methods of survey and design particularly suited to timbered swamp lands and their drainage.

Investigation of the value of the roughness coefficient in Kutter's formula for flow in open channels, results of which are still considered standard for designing such channels.

Survey of terracing practices and results in 1916, followed by measurement of soil and water losses from walled plots in North Carolina.

Creation of the first soil erosion experiment station at Guthrie, Oklahoma, in 1929.

Inauguration of snow surveys in western watersheds as a means of predicting water supplies for irrigation, power, etc., and for minimizing flood hazards.

Duty-of-water studies in deciduous and citrus fruit areas of the West.

Study and promotion of underground storage of water resources.

Capacities of and losses from irrigation conduits, both open and closed, and of many materials; also movement and losses of water in soils.

Revision, with two distinguished colleagues, of drainage and flood protection plans for the Florida Everglades.

Creation of farm tillage machinery laboratory at Auburn, Alabama.

Plow studies leading to improved design permitting substantial savings in draft.

Cotton planting studies leading to the variable depth planter which largely avoids need for replanting.

Extensive studies in fertilizer placement leading to devices and practices that improve germination and yields with greater economy of fertilizing materials.

Mechanical methods of pest control, notably in the case of the European corn borer.

Cotton ginning and fiber laboratories; development of practices, including drying, for production of better lint.

Inauguration of agricultural engineering extension work by the Department of Agriculture.

In most of this, and in much more that should be mentioned if space would permit, Mr. McCrory himself would be the last to overlook or minimize the splendid work done by hundreds of men and scores of institutions. Indeed, he is outstandingly an administrator who has capitalized the efficiency of cooperative activity among bureaus in his own department, other federal agencies, private industry and its associations, and a host of state institutions, notably the agricultural experiment stations. Yet his leadership, his vision, and his critical capacity to evaluate projected plans have given added impetus to countless efforts and enhanced the fruitfulness of many men.

Mr. McCrory has been a member of the American Society of Agricultural Engineers since 1919, and was its president in 1923-24. He also is a member of the American Society of Civil Engineers, American Society for Testing Materials, National Academy of Sciences, the Washington Engineering Society, and Cosmos Club.

For illustration, description, background and objective of the John Deere gold medal, readers are referred to page 458 of AGRICULTURAL ENGINEERING for October 1937. All who know Mr. McCrory's career will concur that he richly deserves the honor which, according to the inscription on the medal, is bestowed for "Distinguished Achievement in the Application of Science and Art to the Soil." Formal presentation will be made at the Society's 1938 annual meeting in California next June.

McCormick Medalist for 1938: E. A. Johnston

FOR the first time in the history of the Cyrus Hall McCormick gold medal, awarded annually by the American Society of Agricultural Engineers, it will be awarded to a man who is a member of the great industrial unit which in over a hundred years has evolved from the invention of the reaper by the man for whom the medal is named. The Society's Jury of Awards has announced as the donee for 1938, Mr. Edward A. Johnston, vice-president in charge of engineering and patents, International Harvester Company.

E. A. JOHNSTON

Though none are privy to deliberations of the Jury, it seems obvious that, as with previous awards, selection has been based not alone on present prominence in the profession, nor yet on a single significant or spectacular achievement, but rather on summation of a long and fruitful career, with critical evaluation of each element as a constructive contribution to the welfare of agriculture and to its place in American life. Indeed, if we accept the era of farm machinery as dating from the inception of the reaper and the steel plow, Mr. Johnston's personal participation in it embraces nearly half its span.

Born August 1, 1875, at Brockport, New York, the boy Johnston at the age of fourteen began a four-year apprenticeship with the Johnston Harvester Company of Batavia, in the same state. Experience in every department laid the foundation for the varied career which now receives this well-merited recognition. At seventeen he filed claim for a patent, issued in due course, on a box-making machine. Thus began the inventive career which for forty years was to average more than four patents a year; to be precise, 162 patents from 1897 to 1937.

While yet eighteen he joined the McCormick Harvesting Machine Company as designer and inventor, and in 1897 the first of his farm machinery patents was issued. The next year he designed and built an automobile, and about the same time he created an auto-mower which in 1900 won first prize at the Paris Exposition.

After eight years in this position, Mr. Johnston became superintendent and designing engineer for the Keystone Company of Rock Falls, Illinois, where he developed and produced a complete line of grain and hay harvesting machinery that won farm favor and went to volume production. In 1905 the Rock Falls concern became a part of the International Harvester Company, and thus brought to our medalist the connection which was to absorb all of his genius from then until now. In that year he designed and built the first auto-buggy which, however crude and quaint it may now appear, served as the pattern for wide imitation and so suited the roads and the needs of the time that production ran into the thousands.

For their manufacture he organized and operated a plant for his company at Akron, Ohio. There he also designed and built five hundred each of roadsters and touring cars, a project soon eclipsed and abandoned because of a greater development—one of the first, if not the very first, commercial motor vehicle. From it, under Mr. Johnston's guidance, has evolved the present-day line of International motor trucks.

In the realm of farm power, he is credited with creation of the model "C" tractor in 1908, the first of the company's models to reach quantity production. He followed it with the Mogul line of tractors and engines. From 1908 to 1914 he was in charge of building, organizing, and operating the company's tractor works in Chicago. In 1915 he went to the general offices as assistant manager of the engineering department, becoming manager a year later. In 1922 he became director of engineering and a member of the executive council, to be followed in 1934 by elevation to his present position.

In the four positions last mentioned he dealt not with a single plant or a single line, but with all of the fifty or sixty machines in the company's broad line, every new creation and every improvement bearing in some measure the impress of his genius and guidance throughout 21 years. Indeed, it is said of him that through expired patents, unpatented ideas, and that most potent of creative forces, the stimulus of competition, there is hardly an item of farm equipment but what, no matter by whom built, is better by virtue of Mr. Johnston's life work.

Probably the most revolutionary, in both content and extent, of the developments directed by him has been the Farmall line of tractors and attached implements which first, on any considerable scale, broke through the barriers of adaptation and economics and admitted power farming to row-crop culture on tracts of ordinary family size. Now, supported on all sides by general-purpose tractors made by many companies, it is quietly working what promises to be the most profound effect on agriculture since the reaper itself.

In contrast to the general-purpose and other tractors, the motor truck and other developments which are in widespread use throughout the world, is Mr. Johnston's thirty years of patience with the perplexing problem of the cotton picker. Like other explorers in this field he saw his early ideas fail of their promise. Unlike most of the others, he never gave up. For the last several of the thirty years he has had machines in the field each season actually picking cotton. When finally released for production—and that goal seems to be in sight—it may well repeat the revolutionary results of the cotton gin and the reaper.

As evidenced by the multitude of his patents, his rise to high executive rank has never divorced Mr. Johnston from personal devotion to the details of design. That incessant application perforce prevented him from taking his deserved place in engineering organizations. However, he has been a member of the Society of Automotive Engineers since 1918. For seven straight years he served it in two or more important capacities, including first and second vice-president, councilor, and chairman or member

of sundry committees, notably those on research and standards.

The McCormick medal awarded annually "For exceptional and meritorious engineering achievement in agriculture," was instituted by the American Society of Agricultural Engineers in 1931, made possible by an endowment established by Mr. Cyrus H. McCormick, Mrs. Emmons Blaine, and Mr. Harold F. McCormick, sons and daughter then surviving of Cyrus Hall McCormick, as a memorial to their father and as recognition to others who, after a hundred years, have made worthy and broadly comparable engineering contributions to the advance of America and its agriculture. It will be formally presented to Mr. Johnston at the 1938 annual meeting of the Society next June, in California.

What Agricultural Engineers Are Doing

FROM THE USDA BUREAU OF AGRICULTURAL ENGINEERING

DESIGNS, cost estimates, and specifications were prepared by M. R. Lewis for a proposed water storage dam for the Southern Great Plains Field Station of the division of dry land agriculture, Bureau of Plant Industry, at Woodward, Oklahoma. The estimated cost is about $42,000. It is proposed to build an earth-fill dam about 30 ft high and 800 ft long. A lined spillway 55 ft wide has its crest 2 ft below the crest of an unlined spillway 200 ft wide. The lined spillway will carry all flows of less than 460 cu ft per sec. The combined maximum capacity of both spillways is 10,000 cu ft per sec. This large spillway capacity, when compared with an estimated annual discharge of 300 acre-feet, indicates the flashy character of the flow.

* * *

Colin A. Taylor reports that analysis of data developed in a study of June-drop in citrus orchards and the effect of cover crop in reducing orchard temperatures indicated that cover crop plots are 4 degrees (F) cooler than clear cultivated plots.

* * *

John O. Reeve, newly appointed junior irrigation engineer, reported for duty at Pomona, California, Nov. 1, and was assigned to assist Colin A. Taylor in his studies of irrigation of citrus trees and other projects.

* * *

In preparation for the season's water spreading studies, Dean C. Muckel installed water-stage recorders on the San Antonio, Cucamonga, and Lower Santa Ana River spreading grounds in southern California. Construction of a 10-ft Parshall flume was started on the lower Cucamonga spreading grounds. This will have a concrete floor with 2-in timbers for the side walls.

* * *

J. C. Marr reports that so far as it has been possible to do so, arrangements have all been made for snow surveys during the coming winter. R. L. Parshall conferred with representatives of various local, state, and government organizations relative to their cooperation in this project. Carl Rohwer located one new snow course, interviewed cooperators, prepared plans and estimates of cost of taking observations during 1938, and prepared maps showing location of snow courses. Geo. D. Clyde brought up to date all stream-flow records for Utah streams, and analyzed snow-cover normals.

* * *

As reported by John G. Sutton, the CCC drainage camps of the Central District have in three years completed more than 147 million sq yd of clearing, 27 million cu yd of excavation, and 168 mi of tile reconditioning, benefiting an estimated 6 million acres of drained agricultural land. They have cleared approximately 4,500 mi of ditches and 460 mi of levees, excavated 2,800 mi of ditches, reconstructed or repaired 200 mi of levees, and leveled 700 mi of spoil banks.

* * *

At the annual meeting of the National Joint Committee on Fertilizer Application in Chicago on November 29, G. A. Cumings discussed several phases of the fertilizer placement research program. Research on fertilizer placement has gradually increased, he reported, from four experiments in 1930 to 119 experiments with 23 crops in 28 states in 1937. One need, he said, is the development of suitable fertilizer-depositing equipment for the farm trade, which meets the requirements definitely indicated by the research work. It is also desirable, he said, to determine which types of machines or devices on the market place the fertilizer in an approved manner.

* * *

E. M. Dieffenbach, with headquarters at Logan, Utah, recently visited southern Idaho to observe the weed eradication methods used there during the present weed eradication campaign conducted cooperatively by federal, state and county agencies. In comparing Idaho and Utah conditions and methods, Mr. Dieffenbach reports that in Idaho the weed infestations are often small enough to justify the use of carbon bisulphide as a soil fumigant, whereas in Utah the infestations are usually too large to permit its use, so clean cultivation and application of chlorates are the common methods there.

* * *

Mechanical corn pickers, Claude K. Shedd reports, were highly successful during the 1937 harvesting season, as shown by tests on the corn production machinery project at Ames, Iowa. A series of tests the latter part of October in four kinds of corn varying in yield from 86.5 to 101.3 bu per acre, showed field losses of from 1.96 to 4.83 per cent of the yield. This is a lower rate of loss than is usually found with hand picking, whereas hand picking has heretofore shown the smaller loss.

* * *

W. R. Humphries returned December 18 from Stoneville, Mississippi where investigations of mechanical cotton pickers were conducted in cooperation with the Bureau of Agricultural Economics and the Delta Experiment Station. Three spindle-type machines and one brush-picker, pneumatic-conveyor type machine were observed during the 1937 season. Observations were made on the field performance of the machines and laboratory analyses of the quality of the cotton ginned from the machine-picked lots. A report of the season's work will be completed as soon as the laboratory data are available.

* * *

E. D. Gordon reports that more than 1,000 core samples were taken from the Prattville field (Alabama) this fall after the cotton harvest, to be used in making observations on the soil density of the various plots. To measure the soil density by stratifications the soil cores were divided into 2-in samples. It was observed that not only is there a wide range of soil densities, but that there is a close relationship between soil density and the type of tillage operations, and a definite inverse relationship between soil density and yield. In what may be termed the root zone the apparent specific gravity readings showed a definite correlation to yield. Below the depth of tillage operations there exists no correlation between density and yield. In a lateral direction from the row there appeared to be definite limits of correlation between yield and density. At 6 in from the row the density down to level of tillage operations proved to be definitely related to yield. At 12 in from the row the correlation was sharply broken off, in the shallow (4-in) tilled plots. In the deeply (8-in) tilled plots, at 12 in the correlation factor is on par with the factor found near the cotton row. In all plots at the row middle there was a sharp decline in the relationship of yield to soil density.

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new development in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

NEWS

Nominations for 1938-39 ASAE Officers

THE Nominating Committee of the American Society of Agricultural Engineers—F. J. Zink (chairman), M. M. Jones and E. M. Mervine—have placed in nomination the following members as candidates for the various Society offices to be filled by the annual election of officers for the Society year 1938-39:

For President

SAMUEL P. LYLE, senior agricultural engineer and extension specialist, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

For Vice-President (One Year)

E. E. BRACKETT, professor of agricultural engineering, University of Nebraska.

J. P. FAIRBANK, extension agricultural engineer, University of California.

For Vice-President (Two Years)

E. C. EASTER, agricultural engineer, Alabama Power Company.

G. A. RIETZ, in charge of rural electrification, General Electric Company.

For Vice-President (Three Years)

F. P. HANSON, manager, merchandise bureau, Caterpillar Tractor Company.

G. D. JONES, agricultural engineer and patents manager, Cleveland Tractor Company.

For Councilor

D. G. CARTER, professor of agricultural engineering, University of Arkansas.

J. C. WOOLEY, professor of agricultural engineering, University of Missouri.

For Nominating Committee

G. W. KABLE, editor "Electricity-on-the-Farm".

L. F. LIVINGSTON, manager, agricultural extension section, E. I. du Pont de Nemours & Company.

E. G. MCKIBBEN, professor of agricultural engineering, Iowa State College.

D. A. MILLIGAN, equipment sales engineer, Cleveland Tractor Company.

C. K. SHEDD, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture.

H. H. SUNDERLIN, manager, sales training division, Caterpillar Tractor Company.

The by-laws of the Society provide that thirty days shall be allowed for additional nominations by special nominating committees, at the expiration of which period (February 20), the Secretary of the Society will mail a letter ballot to all voting members.

Fall Meeting Reflects Sustained Interest

ATTENDANCE broke the 400 mark when agricultural engineers from all sections of the country gathered in Chicago for the fall meeting of the American Society of Agricultural Engineers, November 29 to December 2, 1937. The nucleus of division sessions was occasion for a record number of satellite meetings and conferences of ASAE committees and related groups. Provision in the program for using the entire day preceding the technical sessions as well as evenings and other free hours for special group meetings relieved the technical sessions of some distracting influences.

Opinion apparently was divided as to the way in which the double-schedule or continuous, alternating sessions on Wednesday, December 1, worked out. Favor for the shorter meeting and rapid action was counterbalanced by disapproval of a certain amount of rush and confusion which resulted. The sessions beginning at one o'clock suffered in attendance due to many of the members of those divisions failing to eat lunch during their 11:00 to 1:00 recess.

A lively interest was shown in the tractor fuel session of the Power and Machinery Division. There were evidences of some progress toward a meeting of minds on some fuel problems.

In the farm housing program definite research and extension progress toward better housing was noted.

Several new and interesting viewpoints and developments in rubber tires, traction, and farm transportation units were reported to the Power and Machinery Division.

Progress in the improvement of steel and in methods of its use in farm structures was evidenced in the Farm Structures Division symposium on that subject. Considerable emphasis was placed on new concepts of farm building requirements, materials, and structural methods with which they can economically be met.

The engineering elements in irrigation were reviewed in the joint session of the Power and Machinery, Soil and Water Conservation, and Rural Electric Divisions from the standpoints of power, pumping equipment, and distribution technology.

Aggressive research and industrial progress to increase the usefulness of wood as a building material came to light in another farm structures session.

Roads as engineering works involving their own erosion control problems, and as factors in the control of erosion from farm lands, enjoyed a good hearing in one of the Soil and Water Conservation Division sessions.

Electric fences proved a hot subject among representatives of the Rural Electric Division, and drew extra consideration in an evening roundtable. Deaths and injuries resulting from makeshift equipment were reported and emphasized the importance of getting this potentially useful principle on a safe and sound engineering basis before it is outlawed.

The one paper on wind electric plants, by F. W. Hawthorn, reported dependability and sufficiently low cost to be attractive in windy areas which are also beyond the reach of high lines.

Progress reports of tillage research at the USDA Bureau of Agricultural Engineering Farm Machinery Laboratory at Auburn, Alabama, revealed further basic information on the forces involved in movement of soil by tillage implements. Small combines had their inning at the same session of the Power and Machinery Division.

Among the miscellaneous subjects scheduled by the Farm Structures Division, an analysis of the farm structures market dealt in big figures showing significant correlations between farm purchasing power, volume of farm construction, and percentages of total investment represented by buildings.

A feature of the Rural Electric Division program was the demonstration lecture on "The Romance of Radiations beyond the Visible," by Dr. Samuel G. Hibben, director of applied lighting, Westinghouse Electric and Manufacturing Co. Dr. Hibben showed various new types of experimental bulbs in operation and suggested numerous possible agricultural applications.

Drainage districts, conservation districts, erosion control problems of the railroads, hydrologic research, contour furrowing and miscellaneous other reports of research and developments completed the Soil and Water Conservation Division program.

A symposium on "An Engineering Analysis of Uses for Electricity in Agriculture" brought out a comparatively new angle of approach to electrification problems. Another symposium, on "Rural Electrification Extension Programs," covered ways and means of getting farmers to use available electric conveniences and labor-saving devices, and concluded the Rural Electric Division program.

Related meetings held more or less in conjunction with the ASAE meeting included the National Joint Committee on Fertilizer Application, the agricultural committee of the National Fire Waste Council, the drainage engineering group engaged in the CCC drainage camps program, and the group concerned with the federal wheat storage project. ASAE committees which met included the Research Committee, the Committee on Economy Plowing Matches, the Advisory Committee to the Museum of Science and Industry, the private industry group of the Committee on Extension, and the Jury of Awards.

ASAE Meetings Calendar

February 2, 3, and 4—Meeting of the Southern Section (in conjunction with the annual convention of the Southern Agricultural Workers Assn.), Atlanta, Ga.

June 27 to 30—Annual meeting of the Society, Asilomar at Pacific Grove, Calif.

Refrigeration and Air Conditioning Report

THE REFRIGERATION and Air Conditioning Institute, Inc., of Chicago, has rendered its fourth annual report to the industry, in the form of a loose-leaf book of 14 sections explaining its facilities and service.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

Why a Public Works Department?

COMMENTING editorially on a fine article in its November 11, 1937 issue by Alonzo J. Hammond, who is vice-president of American Engineering Council, the "Engineering News-Record" had the following to say on "Performance and Preparation:"

"A cogent summary of the conditions and reasons that underlie the government for a national public works department is given in this week's leading article, from the pen of A. J. Hammond, past-president of the American Society of Civil Engineers. It should bring home to every engineer that his own fortunes are involved in the question. Efficient, centralized direction of our national public works will of course make public-works construction more efficient and economical; but in addition it will render systematic advance planning and budgeting of federal construction possible, as was brought out in this column a few weeks ago. Through such planning the government will be enabled to hold public works ready for the call of business emergency. The lesson learned during the past half-dozen years, when the collapse of construction threw engineers by the thousands out of work was that the stabilizing power of public-works construction should be held ready for service. A central works department under competent direction would go far to assure this stabilization."

* * *

Utah Society of Professional Engineers

OUT OF the rich Rocky Mountain region comes the American Engineering Council's fiftieth member organization. Founded in Salt Lake City in 1907 as the Utah Society of Engineers, the organization functioned under that name until 1935 when its progressive membership reorganized as the Utah Society of Professional Engineers.

* * *

Federal, State and Local Planning

OPERATIONAL planning of public enterprise is becoming universal, in the United States, according to the annual report of the National Resources Committee released November 10, 1937; and it is indicated that serious efforts are now being made to determine the "strategies of civilizations" and to provide national, social, and economic policies for present and future generations. Engineers congratulate the National Resources Committee and all state and local planning bodies on their good judgment in the adoption of the planning function, but many of those who are most experienced in planning operations question the value of national planning which involves the determination of a pattern of living for future generations.

In reviewing its efforts to stimulate planning and to encourage decentralization of planning activities, the National Resources Committee has pointed out that, in addition to the 46 state planning boards, there are now approximately 400 county planning agencies and more than 1700 similar groups in towns and cities. The Committee predicts that state planning boards will increase their resources and usefulness through closer cooperation with other planning bodies, and expand their activities as state legislatures increase planning appropriations. Of the 1700 municipal planning or zoning agencies, some 1200 have continuous planning boards for making adjustments in zoning ordinances and for initiating plans for physical improvements including public buildings, parks, thoroughfares and the better use of available resources.

Secretary Ickes, in his letter to President Roosevelt transmitting this report, states that "continuous planning is needed for the conservation and wise development of our national resources—both natural and human. With new inventions, new ideals, and new discoveries, no fixed plan or policy will suffice, for any rigid mold or blueprint plan, if strictly adhered to, may restrict our freedom rather than enlarge it. If we adopt as our constant objective to hand down to our children an unimpaired physical inheritance in the natural wealth of this continent, then we must make new plans to meet new conditions."

Many engineers are likely to welcome the philosophy that "no fixed plan or policy will suffice," and most of us will agree that any effort to mold our future may "restrict our freedom rather than enlarge it." Member societies should congratulate Secretary Ickes and encourage him to have that principle firmly established as the guiding influence for the National Resources Committee and all of its subcommittees. In that way, engineers and engineering organizations may be constructive in their efforts to prevent the enforcement of misguided attempts to predetermine an exact plan of social and economic life for unborn generations of our citizens.

On the subject of regional planning, the National Resources Committee says that "there have always been interstate problems, and we have always had to use some kind of negotiation or planning to meet the critical situations as they arise. It is, therefore, nothing new to have interstate compact commissions and planning agencies studying alternative methods of solution for pressing problems which involve more than one state." The report then proceeds to name a number of regional planning activities and "demonstration projects" in the Central Northwest, New England, the Ohio Valley, and the Pacific Northwest where it is said that real progress is being made on such problems as flood control, reclamation work, power policy, etc.

Kaskaskia Valley Studied Intensively

"PHYSICAL, Economic, and Social Aspects of the Valley of the Kaskaskia River" is the title of 300-page mimeographed report (paper-bound, in two sections) prepared by the University of Illinois, the Illinois state surveys and certain departments of the state.

Twenty-seven subject matter aspects of the valley are analyzed in corresponding sections of the report. E. W. Lehmann is author of the section on "Rural Electrification." Other sections of possible interest to agricultural engineers include "Observations on Planning," "Water Resources," "Stream Pollution and Sanitation," "Land Use," "Land Reclamation and Flood Control," "Soil Erosion in the Kaskaskia River Basin," "Economic Aspects of Farm Production and Marketing," and "Maps and Mapping."

Under "Rural Electrification" the valley is analyzed as providing opportunity for extension of service, the farming area being comparable to other areas in the state and the degree of electrification less than half the average for the state.

A wide variation in farm land use in the valley, which is all subject to the same general climate and precipitation, is explained in summary as largely due to wide diversification of soils from the standpoint of crop adaptation, topography, and resulting agricultural value. An interesting technique of summarizing areas, their present production capacities, and response to treatment is given.

A limited number of copies of the report is available through W. C. Huntington, department of civil engineering, University of Illinois.

New ASAE Constitution Adopted

A PROPOSED revision of the constitution of the American Society of Agricultural Engineers, first presented to the corporate members of the Society last May, was submitted to the membership in October for final action by letter ballot. A canvass of the ballots cast showed that out of a total of 361 votes all but five were in favor of adoption. Accordingly the Council of the Society at its meeting in Chicago recently voted to announce that the new constitution had been formally adopted and was therefore in effect.

The principal change effected by the Society's new constitution is in the matter of membership grades. It provides that the corporate members shall consist of Fellows, Members, and Junior Members, and that in addition there shall be Honorary Members, Associates, and Student-members.

Copies of the revised constitution will later be available in printed form, but until then any member may obtain a mimeograph copy of it by writing the Secretary's office.

William B. Clarkson

MEMBERS of the American Society of Agricultural Engineers, especially those whose membership dates back to the first decade of the Society's existence, will regret to learn of the passing of a highly respected, much-loved former member, William B. Clarkson, who for many years was identified with the King Ventilating Company, during the past few years having served as president of the company.

Mr. Clarkson's name occupies a prominent place in the record of Society activities in its earlier years. He gave a great deal of his time and thought to the committee work of the farm structures group, and the encouragement and inspiration which he gave to that activity stand as a fine memorial to his service to the agricultural engineering profession.

Mr. Clarkson was elected to membership in the Society in 1917, and in addition to his many committee activities also served one term as a vice-president of the Society. He was also a member of the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers. Mr. Clarkson had many warm personal friends in the agricultural engineering field who will deeply regret his passing.

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GOODYEAR

MORE FARM TRACTORS ARE EQUIPPED WITH GOODYEAR TIRES THAN ANY OTHER KIND

Personals

Charles A. Bennett is senior author of Leaflet No. 151 of the USDA, entitled "Effects of Feeds and Saw Speeds on Cotton Turn-Out and Quality."

Wheeler McMillen, editorial director of "The Country Home," has been elected president of the National Farm Chemurgic Council.

John R. Orelind recently joined the Canton, Illinois, works of the International Harvester Company as experimental engineer. He was previously connected in a similar capacity with the Minneapolis-Moline Power Implement Company.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the December issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

C. R. Case, field engineer, Goodyear Tire & Rubber Co., Akron, Ohio.

H. H. Cline, owner and manager, Cline & Company, Eagle Grove, Iowa.

Russell H. Gist, state agent, agricultural extension division, West Virginia University, Morgantown, W. Va. (Mail) Oglebay Hall.

Horace E. Holman, associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 939 J St., Bedford, Ind.

Leo E. Holman, extension assistant in agricultural engineering, North Dakota Agricultural College, Fargo, N. Dak.

F. M. Hunter, rural electrification specialist, Mississippi State College, State College, Miss.

R. L. McGrath, associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 1911 Key Blvd., Arlington, Va.

Joseph K. Park, instructor in agricultural engineering, University of Minnesota, University Farm, St. Paul, Minn.

C. G. Rohrer, manager, Sibley Farms, Sibley, Ill.

Howard C. Rutt, rural sales engineer, Public Service Co. of Northern Illinois, Evanston, Ill. (Mail) 1946 McDaniel Ave.

Dale Ryman, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 512 Quincy St., Rapid City, S. Dak.

J. H. Wheatley Jr., associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 603 S. 21st St., Muskogee, Okla.

Carl Widseth, agricultural field representative, Portland Cement Ass'n., Minneapolis, Minn. (Mail) 2018 Carroll Ave., St. Paul, Minn.

Lowell A. Yost, associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 156 Sixth St., SW, Huron, S. Dak.

TRANSFER OF GRADE

C. B. Richey, instructor in farm power and machinery, Purdue University, Lafayette, Ind. (Transfer from Junior.)

Student Branch News

GEORGIA

GEORGIA'S Student Branch held their last meeting of the fall quarter in Barrow Hall on the University of Georgia campus, Monday evening, December 6.

Officers elected for the winter quarter were L. L. Reaves, president; G. W. Clark, vice-president; F. G. Blitch, secretary, and H. S. Glenn, scribe.

C. O. Shiver, president for the fall quarter, received his honor key at this meeting. Shiver has obtained seven honor points, whereas only six are necessary to obtain the honor key.

The program for the evening was a motion picture dealing with light, sponsored by the Georgia agricultural extension service. Each of the newly elected officers expressed their appreciation to the Branch for having been chosen to hold office during the winter quarter.

Refreshments in the form of a box of apples were supplied by Charles Harden. The Branch expressed its appreciation for the treat by the manner in which each member participated in devouring the fruit.

—*F. L. Burrell, Scribe.*

MISSOURI

MISSOURI'S Student Branch of the ASAE presented an interesting series of programs the past two months. Speeches were given by student members of the club, and graded by fellow students. The series so far has included speeches on "The National Corn-Husking Contest," "Drainage Work in Southeast Missouri," "Relation of Soil Erosion to Flood Control," "Erosion Work at Kahoka Missouri," and "Rural Electrification." We find the talks based on personal experience are especially informative and entertaining. Slides and illustrations also add much to the effectiveness of the talk.

Plans are being made for the publication of a Missouri Branch agricultural engineering magazine. Our president, Hermann Hall, has appointed Charles Timm as editor, and Donald Brooker and Norman Teter as assistant editors. Plans were also formulated for a model farm showing modern methods of erosion control, building design, and rural electrification.—*Norman C. Teter, Secretary.*

OREGON

OREGON State's Student Branch met soon after school started last September and elected the following officers: Gerald Kubin, president; Larry Swarner, vice-president; Ted Kirsch, secretary; John Bursik, treasurer; and Elgin Cornett, scribe.

Branch meeting dates are not regular, but are determined in advance for each meeting. Four meetings have been held this quarter with an average attendance of 75 per cent. President Kubin meets monthly with the Agricultural School Council consisting of all the student presidents of the various departments.

At the last Branch meeting F. E. Price, assistant dean of agriculture, gave a summary of the high points in the fall meeting of the ASAE at Chicago. Some moving pictures of interesting scenes were included in the program for one of the meetings. The Oregon group are expecting to see the student branch pictures early next quarter.

Our activities have included an active radio committee that broadcasts over the college station once a week. A number of jobs such as ditching and orchard clearing have been organized and executed for the purpose of securing funds. The fall picnic was held around the big secluded cabin in the Peavy Arboretum and was a memorable gathering.

Among our members is Jaun Bazo, a student from Peru. Edward Stastny, president of the National Council of ASAE Student Branches is laying plans for a big meeting in California next June.—*Elgin Cornett, Scribe.*

IOWA

AT IOWA State College the ASAE Student Branch started the fall quarter activities with a mixer. This is an annual affair and consisted of a dinner given by the faculty of agricultural engineering. The mixer gave everybody a chance to get acquainted with the newly enrolled freshmen, as well as becoming better acquainted with the faculty members and their wives.

We are having two business meetings a month this quarter, since time is lacking in our seminar periods. Three seminar reports are scheduled for each week, due to the increased enrollment.

On November 7, nine of the seniors went on a five-day inspection trip. Traveling in two automobiles, we visited industrial plants at Moline, Peoria, and Rockford in Illinois, and Charles City and Mason City in Iowa.

The social event of the season was staged November 27, when we initiated the "Grease Monkeys Bawl." This was a very informal dance with costumes of every description represented. Prizes were given for the best dressed couple. The setting for the event was appropriately in the show room of the agricultural engineering building. The machinery was placed outside for the evening, with only enough left to lend atmosphere. The spacious painted and waxed cement floor lent room for 104 couples who relentlessly did the "Big Apple." At $1.25 a couple we cleared over $30.00. Everyone had such a good time that it will undoubtedly be an annual event.

—*Harris Hart, Secretary.*

Student Branch Film Circulates

STUDENT Branches of ASAE at Ohio, Kansas, and Nebraska have already shown the film "Agricultural Engineers of Tomorrow." Additional showings already scheduled include Oregon, January 12; Georgia, January 24; Idaho, February 1; Missouri, February 8; and Texas, February 15.

Allowing time for shipment, this film will be available for other branches February 20. All dates thereafter are still open. Additional Branches requesting use of this film should specify first, second, and third preferences as to dates. First preferences are granted whenever they do not conflict with previous requests.

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AGRICULTURAL EXPLOSIVES

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, principal agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

ANALYSIS AND CONTROL OF LANDSLIDES, *R. G. Hennes.* Wash. Engin. Expt. Sta. Bul. 91 (1936), pp. 57, figs. 17. The purpose of this bulletin is to develop, in outline, an applied science of landslide control. The approach to this goal consists of (1) investigation of the nature of the shearing strength of soil, (2) investigation of the load conditions which result in exceeding this strength, and (3) application of the theory to the practical problems of analysis and control.

Part 1 deals with friction and cohesion, part 2 with the computation of the stability of slopes, and part 3 with the actual occurrence of landslides. The principles thus developed are then applied to the selection of proper methods of control. A method for determining the proper spacing of piles is developed, and methods are suggested for the design of works for drainage of gravitational and of capillary water.

It is pointed out that the application of new methods to problems connected with landslides has become possible through the development of tests to measure the physical properties of soils. To a large extent the efficiency of landslide control must depend on the accuracy with which the properties of soil have been determined for the individual case.

THE INFLUENCE OF DAY LENGTH IN CONNECTION WITH ARTIFICIAL ILLUMINATION OF PLANTS IN WINTER. [trans. title], *J. W. M. Roodenburg.* Ber. Deut. Bot. Gesell., 55 (1937), No. 1, pp. 5-32, pls. 5, fig. 1. It is shown that with medium light intensities and times of illumination leaf development is proportional to the light quantity (duration × intensity). Thus the leaf develops in direct correlation with CO_2 assimilation. On the other hand the specific influence of day length is expressed in relation to induction of the flowering period, and, within wide limits, it stands in no relation to light intensity. Here the specific effect depends exclusively on the duration of daily illumination. From these and other experimental results with cucumbers and strawberries grown in the greenhouse, it is postulated that the lack of any relation at all with CO_2 assimilation and the very far-reaching agreement with the cell-stretching hormones render it probable that the length of the daily light period in one manner or another controls the growth conditions of the plant.

EFFECT OF LIGHT ON SOLANINE SYNTHESIS IN THE POTATO TUBER, *H. W. Conner.* Plant Physiol., 12 (1937), No. 1, pp. 79-98, figs. 6. "A new analytical method has been developed for the quantitative estimation of solanine in the presence of solanidine, based upon the amounts of sugars set free on acid hydrolysis. Upon irradiation by a mercury arc in Uviol or by Mazda lamps, potato tubers increased in solanine. This was accompanied by the appearance of anthocyanin in the sprouts. Wave lengths which are efficient for glucose synthesis did not induce a significant increase in solanine, but did result in an increase of chlorophyll. Ultraviolet rays of about 0.3 mu are effective for solanine formation but not for chlorophyll elaboration."

The bibliography contains 51 references.

A STUDY OF SELECTED TYPES OF DOMESTIC GAS STOVES, *A. E. Baragar.* Nebraska Sta. Res. Bul. 86 (1936), pp. 74, figs. 33. Seven domestic gas stoves, representing several types of surface burners, burner assemblies, and oven construction, were operated on natural gas of an average heat content of 1,009 Btu per cubic foot, average sp gr 0.72, and a normal pressure of 7 in of water. Six types of surface burners were tested, including the star, cast iron round, die-cast round, Y, daisy, and continuous or ribbon-flame types. These are described and illustrated by photographs, with types of utensils used.

In the surface burner performance tests, the technics for all of which are described, the thermal efficiency was found to depend upon the size and kind of utensil, the construction of the burner, and the type of stove top and grate construction, and to be independent of the quantity of water used, the length of the injector tube, and the gas rate if other factors were kept unchanged. Efficiencies determined by long-time tests in which water was actually boiled were found to be comparable with the average efficiencies for short-time tests in which the water was heated from an initial temperature of 75 F to a final temperature of 200. The time of heating was found to be a function of the gas rate and the efficiency of the burner. However, the gas rate should not be so high as to produce carbon monoxide. The distribution of heat from the burner, as determined by the scorch-pattern method, was found to be a function of the utensil as well as the shape of the burner. Automatic lighters were not uniformly satisfactory or dependable. Boilover tests with either soap or starch solution revealed features of construction of burners and lighters that might otherwise have been missed, such as differences in ease of cleaning burner and cooking top.

From the technical data obtained concerning the performance of the surface burners of the types studied, it is thought that the performance of similar types of burners can be predicted. The heat distribution tests, automatic lighter tests, and boilover tests can be made by anyone. "If these tests are performed and then the efficiency judged on the basis of known data, a fairly comprehensive idea of what a particular burner will do may be obtained."

The oven tests included calibration of thermostat, determination of oven heat capacity, rate of cooling from an initial temperature of 550 F, empty oven heat loss, surface temperature and internal heat distribution, open door heat loss, and analysis of the flue gas. The data obtained in these tests showed that it is impossible to predict the performance of an oven in terms of known factors from other ovens. The assumption that actual oven temperatures will agree with the dial setting was invalid at the 400 F mark for four of the seven ovens tested. After adjustment of the thermostat so that the dial setting of 400 F agreed with the actual oven temperature, temperature as low as 300 F were obtainable with only two of the ovens. Whenever low temperatures could not be obtained, the fault was usually in the burner design rather than in the thermostat. Changes in the burner design of two of the ovens made it possible to produce the low-temperature readings. All of the ovens met the requirement of the American Gas Association for oven heating capacity. The heat loss data showed that, although all of the ovens were insulated, much heat was lost, chiefly by losses through the flue and through poorly fitting doors. The surface temperatures were low and the heat distributions within the ovens quite uniform.

Actual cooking tests, both on surface burners and in the ovens, to determine the amount of heat required and variations in the finished products gave results which in general confirmed the technical tests.

Additional information on the laboratory in which the work was done and its equipment, the technic for meter calibration, the construction and operation of a test box for testing surface burners, and data on the effect of temperature on gas rate for type A burners are given in a series of appendixes.

SUPPLEMENTARY ILLUMINATION FROM MAZDA, MERCURY AND NEON LAMPS ON SOME GREENHOUSE PLANTS, *G. H. Poesch.* Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 637, 638. Normal light and normal light plus 4 hr of supplementary light from (1) two 225-w clear glass Mazda lamps, (2) 450 w of neon lamps, and (3) 450 w from mercury vapor lamps, were compared at the Ohio State University for pansies, chrysanthemums, and other ornamentals. In every case the plants under Mazda lamps had longer stems but the quality of the flowers was not reduced. The color of the foliage was paler under supplementary light. The records showed that the Mazda lamps were superior to both neon and mercury in promoting earliness of bloom, total production, and stem length.

EXPERIMENTS ON ELECTRIC, COAL, GAS, KEROSENE, AND MANURE-HEATED HOTBEDS, *G. J. Stout, W. B. Mack, J. E. Nicholas,* and *D. C. Sprague.* Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 605-609. In this further contribution from the Pennsylvania Experiment Station, the authors present more of the technical features of the investigation. Reports on plant growth for two growing seasons showed quicker germination and earlier appearance of the seedlings when the source of heat was below the soil surface. Manure-heated beds produced plants of more stocky growth, and in the case of the tomato the plants weighed nearly twice as much each as from any other treatment at the time of lifting for field planting. *(Continued on page 44)*

OUTSTANDING NEW TRACTOR TIRE

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Both rubber and cords specially processed for resistance to sun and weather for life of tire.

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Agricultural Engineering Digest

(Continued from page 42)

SOME PHYSICO-CHEMICAL RELATIONSHIPS FOUND IN FOUR EROSIVE SOILS OF THE PIEDMONT PLATEAU REGION, *H. T. Rogers.* Jour. Amer. Soc. Agron., 29 (1937), No. 1, pp. 1-9, fig. 1. Noting that "the clay pan nature of the B horizon of the Iredell, White Store, Helena, and Orange soils of the Piedmont Plateau region, linked with their apparent susceptibility to severe erosion, suggested a comparative study of their profiles", the author of this contribution from the Michigan Experiment Station reports such a study and finds that "an analysis of the data obtained . . . reveals some significant relationships between certain physical and chemical properties.

"A correlation coefficient of 0.923 ± 0.358 was found when hygroscopic water content was correlated with cation exchange capacity. These two properties are more closely related than percentage colloid and cation exchange capacity (correlation coefficient 0.752 ± 0.1053). This indicates that the ability of soil colloids to hold water against evaporation forces is an accurate measure of their ability to absorb cations in ionic exchange. A high negative correlation (-0.712 ± 0.1196) existed between H-ion concentration and percentage base saturation. The data obtained show that there is very little relationship between H-ion concentration and total exchangeable hydrogen in soils with widely different cation exchange capacities. High correlation coefficients obtained for both hygroscopic water and maximum water-holding capacity and hygroscopic water moisture equivalent show that any one of these values may be calculated from either of the others by means of a constant, with a high degree of accuracy."

THE LIGHT FACTOR IN PHYSIOLOGICAL PROCESSES. [trans. title], *A. Seybold.* Jahrb. Wiss. Bot., 82 (1936), No. 5, pp. 741-795, figs. 20. The author considers the physiological effects of light quality and quantity from different parts of the spectrum on sun, shade, and water plants; compares artificial light in these respects; and discusses the light field in nature and under experimental conditions with reference to the germination of seeds and of fern spores, in relation to deciduous leaves and to transpiration resistance, and the light absorption of carotinoids.

THE EFFECT OF ALTERNATE PERIODS OF LIGHT AND DARKNESS OF SHORT DURATION ON THE GROWTH OF THE CUCUMBER, *G. B. Portsmouth.* Ann. Bot. [London], n. ser., 1 (1937), No. 1, pp. 175-189, figs. 6. The much lower growth rate with short-period intermittent light was shown to result from reduction in the maximum size of the individual leaves produced and from delay in unfolding of the successive leaves. The main effect of variation in the period of alternation proved to be due to variations in net assimilation rate per unit area. The carbohydrate supply appeared adequate to maintain leaf growth near the optimum both under continuous light and with 12-hr alternations. Observations of stomatal aperture showed part, at least, of the differences in assimilation rates to be due to their closure with the 1-min alternations.

The necessity of a considerable period of darkness for the maintenance of high assimilation rates is postulated in explanation of the results presented.

STUDIES TO DETERMINE THE EFFECT OF "FREON" IN THE ATMOSPHERE UPON APPLES IN COLD STORAGE, *C. E. Baker.* Amer. Soc. Hort. Sci. Proc., 32 (1935), p. 214. "Freon", a proprietary refrigerant of practically no odor and when used as a compressible gas of much lower temperature-pressure relationship than ammonia, was studied by Purdue University as to its effect in various concentrations and at various temperatures on Delicious, Golden Delicious, and Winesap apples. Under the prevailing conditions, there was noted no injury to the fruit that could be attributed to the gas except when the air was almost completely replaced. When the concentration simulated that involving refrigerant leaks of considerable extent and duration, no injury was observed. Considerable quantities of the gas were inhaled by the author without apparent harm.

STUDIES ON THE EFFECT OF HUMIDITY IN THE COLD STORAGE OF FRUITS, *F. W. Allen* and *W. T. Pentzer.* Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 215-223, figs. 4. In studies conducted jointly by the University of California and the U. S. Department of Agriculture, it was observed that in the case of Emperor grapes saturated atmospheres were needed to approach suspension of moisture loss and that transpiration increased with each decrease in relative humidity down to 40 per cent. Weight loss of 1.2 per cent did not cause shriveling. A relative humidity of 85 per cent proved most satisfactory for Emperor grapes. Likewise with apricots, plums, peaches, and apples, a saturated atmosphere was required to prevent moisture loss. High relative humidity had no apparent detrimental effect on pears or apples and little upon sound plums held at 32 F., although some mold appeared on the exterior of the packages after 4 to 8 weeks. Apricots held for 10 days at a relative humidity of 95 to 100 per cent and at 50 F tended to take on a watery appearance before becoming fully ripe. In general, deciduous fruits held at about 32 F were most attractive in appearance and texture when the humidity was maintained at 90 per cent or above.

STRUCTURE, OCCURENCE, AND PROPERTIES OF COMPRESSION WOOD, *M. Y. Pillow* and *R. F. Luxford.* U. S. Dept. Agr., Tech. Bul. 546 (1937), p. 32, pls. 9, figs. 8. Compression wood, one of the abnormal types formed by coniferous species under certain environmental conditions, as a rule on the lower sides of non-vertical trunks and branches, is characterized by high and irregular longitudinal shrinkage, low strength for its weight, and excessive hardness. An increase in the amount of deviation of trunks from the vertical, or an increase in the rate of diameter increment of individual trees, or both, tend to increase the formation of compression wood.

Microscopical examination showed the summerwood tracheids of compression wood to be nearly circular in cross section as compared with a rectangular aspect in normal wood. The fibrils of the secondary cell walls in the compression wood made a higher angle in relation to the longest axis of the cells. The lignin content was slightly higher and the cellulose content slightly lower in compression wood. Pronounced compression wood was from 15 to 40 per cent heavier than normal wood and longitudinal shrinkage in drying was much greater. Transverse shrinkage was less than normal. The lower strength properties in compression wood are associated closely with the differences in the slope of the fibrils. When manufactured into lumber, compression wood is accountable for much bowing and twisting.

Among silvicultural measures suggested to reduce compression wood are the early removal of defective and crooked trees, proper spacing to insure uniform growth, and the avoidance of large and irregular openings in the crown canopy to permit the entrance of violent winds.

FILM CHARACTERISTICS: EFFECT ON RESPONSE OF FLUID MILK TO ULTRAVIOLET RADIATION, *H. H. Beck and K. G. Weckel.* Indus. and Engin. Chem., 28 (1936), No. 11, pp. 1251-1254, figs. 7. Employing a light beam reflecting method as described above, the authors have determined the thickness, velocity of flow and travel time of controlled thin flowing films of milk passing over a metal surface. Empirical formulas are presented for expressing these values as power functions of the film capacity (pounds per foot per hour). The character of the finish of the metal affects the thickness and other characteristics of the flowing film, and the degree of inclination of the surface also affects the film thickness. In a study of the relation between the thickness, velocity, and travel time of the film to the antirachitic potency acquired by the milk from ultraviolet radiation, it is shown that vitamin D potency is directly proportional to the travel time, thus emphasizing the importance of time in the irradiation of milk.

MILK: EFFECT OF DIFFERENT SOURCES OF RADIANT ENERGY ON FLAVOR AND ANTIRACHITIC POTENCY, *K. G. Weckel, H. C. Jackson, R. Haman, and H. Steenbock.* Indus. and Engin. Chem. 28 (1936), No. 6, pp. 653-656, figs. 3. These experiments, conducted at the Wisconsin Experiment Station, represent an attempt to determine what part of the spectrum of various available sources of ultraviolet are particularly instrumental in producing an "activated flavor" in irradiated milk. Three sources of radiant energy were employed, namely, the carbon arc (including five types of carbon electrodes), the quartz mercury-vapor arc, and the cold-quartz arc. Identical milk samples were irradiated until a uniform intensity of flavor was produced when the energy from each source was transmitted through quartz and through glass. There was a marked variation in the time required and the total energy expended from the different sources of irradiation to produce a uniform flavor change, and a like variation in the dgree of antirachitic potency acquired by the milk was noted. It is shown that the flavor changes are caused by that part of the spectrum known to have an antirachitic effect as well as to parts of the spectrum devoid of such properties. The data indicate that within a spectral range below 3,100 au the energy in wave lengths less than 2,600 au is more active in flavor production than wave lengths between 2,600 and 3,100. Similarly, in a spectral region from 3,100 to 7,000, radiations of from 3,100 to 3,800 are more active in this respect than those from 3,800 to 7,000 au. *(Continued on page 46)*

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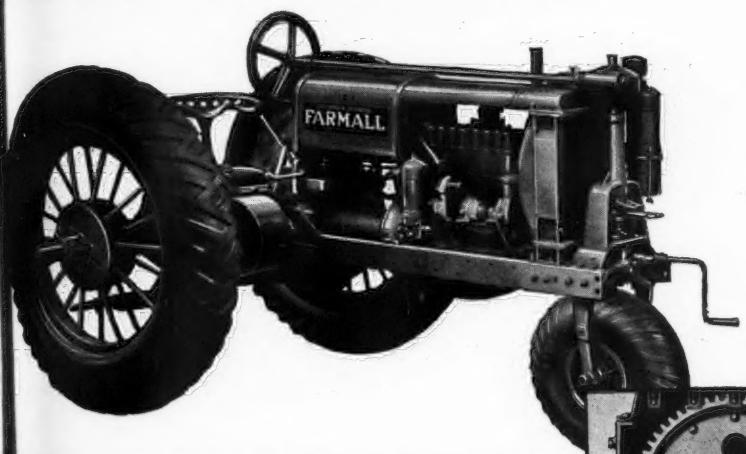
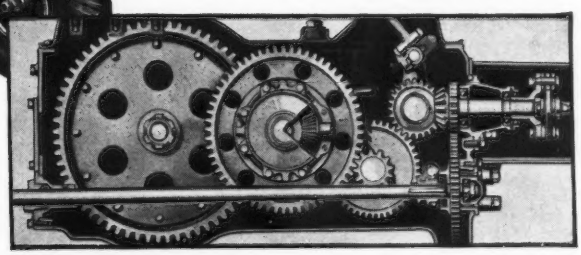
ALLOY NICKEL STEELS



● *Side view showing details of engine containing numerous Nickel Alloy Steel parts.*

● *Close-up of the Farmall's transmission assembly, made more wear and shock-resistant with Nickel Steels.*



● This sturdy Farmall, made by International Harvester, is an exceptionally long-lived product, capable of withstanding heavy shocks, stresses and wear because where these destructive forces are greatest you'll find the Nickel Alloy Steels.

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SOIL AND WATER CONSERVATION INVESTIGATIONS, *G. W. Musgrave* and *R. A. Norton*. U. S. Dept. Agr., Tech. Bul. 558 (1937), pp. 182, figs. 59. This is a report of soil and water investigations made at the Soil Conservation Experiment Station in the Missouri Valley loess region at Clarinda, Iowa. It has been conducted cooperatively between the Soil Conservation Service and the Iowa Experiment Station. This is one of the first publications dealing with the technical phases of the work of the soil erosion experiment stations. It is perhaps the first report of a continuous series of experiments on the measurements of soil and water losses from specific field conditions.

Preliminary data on canopy interception indicate the importance of the subject and the marked effects which various types of vegetation may have in the protection of the land surface. It seems probable that the interception of rain by the plant canopy may readily account for a considerable portion of the control of erosion and runoff which is so commonly noted for alfalfa, clover, bluegrass, and even small grain and corn when the latter are fully developed.

Studies indicating the relative infiltration by water of two important soils of the problem area are reported and show marked differences, the Marshall silt loam having an infiltration rate from 7 to 10 times that of the Shelby silt loam. This difference is sufficient in many instances to represent a greater total amount of water than that which ordinarily is placed under control by common treatments.

The infiltration studies have been extended to determine some of the more important factors which affect the rate of runoff and erosion on these two soils, with the result that soil porosity is indicated as perhaps the most important single factor. The soil moisture content and the vegetative cover are of less importance in their effect upon the infiltration rate *per se*. Soil moisture apparently reduces infiltration on these two soils approximately in proportion to the space volume which it occupies. Vegetative cover may increase total infiltration through its effect in reducing the rate of runoff. It is doubtful whether any increase in rate of infiltration may be attributed, for example, to root effects of growing plants. Insofar as vegetative cover prevents the application of turbid water to the soil profile, normal infiltration is maintained thereby as shown by other investigators.

The increase in soil porosity resulting from the application of organic matter to the surface of a normal profile exerts comprehensive effects upon water conservation. Such treatment has significantly (1) increased percolate through 3-ft profiles of both permeable and relatively impermeable soils by large proportions, (2) decreased runoff, and (3) increased the store of potentially available water. Such treatments have not exerted any marked effects upon evaporation. The treatments have reduced erosion by large amounts.

The potentially available water (rainfall less runoff) has been increased by about 2 surface inches a year in the Marshall, and by about 1.6 surface inches a year in the Shelby soil series by these treatments.

The relationship between land slope and the capacity of surface-impounding treatments is shown. As the land slope is increased, impounding is decreased so rapidly that a treatment which will impound 2.5 in on level land will impound less than one-fourth as much on a 15-per cent slope. This is an important consideration in connection with the design of control measures for different land slopes.

The control of runoff is the product of a large number of factors. The average runoff from manured corn has been reduced to 10 per cent of the total effective precipitation, from bluegrass to 6 per cent, alfalfa 6, clover 2, and from contour-listed corn to a mere trace. A more conservative view of the effect of these treatments in controlling runoff is found in the minimum reduction which has occurred for any rain, or the maximum runoff which has been found during the course of the experiment. From manured land in corn, the maximum percentage of runoff from any rain has been 43 per cent, from contoured listed corn 19, from bluegrass 14, from clover 6, and from alfalfa 5 per cent. It is thought, therefore, that these amounts may be used in estimating the effects of treatments under general use.

The density of runoff is markedly affected by a large number of factors. The amount of soil carried by a cubic foot of runoff from bluegrass has averaged 0.19 lb, from continuous alfalfa 0.19, and from rotation clover 0.10 lb of soil per cubic foot. These figures may be contrasted with a density of more than 5 lb per cubic foot from continuous corn on eroded soil, continuous corn with rows in the direction of slope, and from fallow land, whether treated or untreated.

The effect of adding organic matter to Marshall silt loam which was excessively eroded was to greatly reduce runoff and erosion and to markedly increase soil moisture, rate of growth, and yield of corn. Green manure in the form of sweetclover produced yields above 80 bu of corn per acre 2 yr after artificially eroding the profile to a depth of 12 in.

Strip cropping is shown to be a somewhat different practice on the permeable Marshall silt loam than is generally in use over the country today on less permeable soils. Combining primarily the effects of surface impounding and infiltration, theoretical protection equivalent to the maximum rain of a 15 to 20-yr frequency may be secured through minor modifications of present farm practices.

Additional protection may be provided by winter cover crops and the incorporation of organic matter in the soil in economical and practical ways. The study of slope lengths has revealed the uncertainty lying in an attempted estimate of the optimum width of crop strip.

Detailed studies of the costs of construction of about 10 miles of terraces reveal that:

1 Of three different sizes of terracing outfits covering the range of tractor power which might be available, respectively, to the operator of an ordinary-sized corn belt farm, an extra large farm, and a group of farms or a small contractor engaged in earth-moving operations, there was very little difference in cost per unit length of terrace constructed between a 10 and a 15-hp wheel-type tractor. A 15-hp track-laying-type tractor built terraces for less than 60 per cent as much per unit of length as either of the wheel-type tractors. The depreciation and interest on the investments were not considered in any of these computations.

2 Experienced grader and tractor operators may be able to reduce the cost of terrace construction to approximately 70 per cent of that entailed by inexperienced operators.

3 With soil in good condition for handling by the grader it may be possible to build terraces with only 65 per cent as much cost as will be required when the soil is hard and dry; although usually the most satisfactory time of year for terracing work, from the standpoint of men and machinery available to do the work, is during the hot, dry summer months following oat harvest.

4 Occurrence of gullies in a field may increase the cost of terracing by as much as 20 to 25 per cent in the Marshall silt loam area.

5 The cost of building a terrace from 100 to 150 ft long is nearly twice as great per unit of length as is that required for construction of a terrace 1,600 ft long. This is due to the great amount of lost time in turning at the ends of the terrace.

Suspended-net, woven-wire dams have not proved very satisfactory in gullies in which small amounts of water flow continuously. The Nebraska-type brush dam with suitable backing of woven wire on the upstream side seems quite satisfactory for ordinary types of gully control. For sidehill gullies, probably the most satisfactory control is terracing near the tops of the hills in order to prevent cutting at the head of the gully, then diverting water out of gullies which have already started and fencing them to keep out livestock.

Terrace outlet ditches have been controlled quite satisfactorily by stake and rock checks reinforced by sod strips both above and below each check. Plank checks with sod strips above and below have shown fair success, but the observation has not been in progress long enough to permit drawing very definite conclusions.

Studies of the operation of farm machinery over terraced areas during 4 yr have indicated varying degrees of success with the different implements. A 10-ft corrugated roller was found to operate quite satisfactorily parallel to the terraces. A 14-ft disk harrow of standard construction seemed to lack somewhat in flexibility and clearance to provide the utmost in satisfactory operation. A 16-7 fertilizer grain drill was found to be too lightly constructed to stand the strain due to operation on uneven ground either parallel to or across terraces.

A 20-ft flexible spike-tooth harrow of the pipe-bar type with a specially designed harrow cart has been found to operate very satisfactorily either parallel to or across terraces, but more especially when used up and down the hills at nearly right angles to the terraces. An 8-ft power-driven grain binder was operated on terraced land with only partial success. Lack of clearance and flexibility for operation over uneven ground seemed to cause most trouble.

Three-row corn planting equipment functioned fairly well, but difficulty was encountered with the three-row cultivating equipment mounted on the same tractor. Two-row equipment might operate more satisfactorily.

Of three long, variable-graded terraces with vertical spacings of 4, 5, and 6 ft, the terrace with intermediate spacing lost the greatest amounts of soil and water per *(Continued on page 48)*

DIESEL power puts real economy into the performance of this TD-40 TracTracTor, shown disking a quarter-section of new breaking. Easy-starting McCormick-Deering Diesel Engines are available in three McCormick-Deering Tractors: Model TD-40 TracTracTor, Model TD-35 TracTracTor, and Model WD-40 Wheel Tractor. Ask for complete information.

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McCORMICK-DEERING

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unit of area and the one with the narrowest spacing lost more than the one with the widest spacing.

Of three long, uniform-graded terraces with vertical spacings of 4, 5, and 6 ft, the terrace with the widest spacing lost more soil and water per unit of area than either of the others.

In general, the flatter the grade of long, variable-graded terraces or long uniform graded terraces with the same vertical spacings, the smaller the losses in soil and water.

There is a slight tendency for short terraces to lose more soil and water per unit of area than is the case with long terraces. Level terraces with open ends have operated very satisfactorily so long as they were kept on a good quality of Marshall soil. Level terraces with closed ends have so far not proved satisfactory.

A terrace planted to continuous corn shows greater losses of soil and water than those planted to either first or second-year corn, oats, or clover. No very significant differences have been noted between any of the other four crops when compared among themselves.

An appendix includes additional tabular data on precipitation and runoff as related to erosion.

REDUCTION OF DAYLIGHT PERIOD ON ASTERS, *A. Laurie* and *D. Foote*. Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 639-641. Further information is presented on the results of photoperiodic studies with garden asters. Reduction of daylight induced earliness in all seven varieites, but in Royal Shell Pink the flowers produced were on such short stems as to be of little economic value. In most cases reduced light resulted in slightly smaller flowers. Supplemental light used on seedlings for two weeks prior to transplanting out of doors had no marked effect on subsequent behavior.

A SUBIRRIGATION METHOD OF SUPPLYING NUTRIENT SOLUTIONS TO PLANTS GROWING UNDER COMMERCIAL AND EXPERIMENTAL CONDITIONS, *R. B. Withrow* and *J. P. Biebel*. Jour. Agr. Res. [U. S.], 53 (1936), No. 9, pp. 693-701, figs. 3. From the Indiana Experiment Station, "a subirrigation method of supplying nutrient solutions to plants growing in sand culture which lends itself to large-scale production is described. It consists in principle of pumping nutrients from a submerged reservoir into the bottom of a shallow bed of fine gravel or cinders with a centrifugal pump. The pump is controlled by an electric time switch which stops the operation when the bench is flooded. The solution then flows back into the tank through the pump by gravity.

"Modifications of the method are discussed for use in experimental set-ups on a small scale. . . .

"The advantages of the system are (1) frequent and complete flushing of the roots with air and nutrient solution, (2) economy of nutrients, since the solution drains back into the tank again, and (3) completely automatic operation over long periods of time."

Chemurgic Publication Started

PROCEEDINGS of the third Dearborn conference of agriculture, science, and industry have been published by National Farm Chemurgic Council in Volume 1, Number 1 of the "Farm Chemurgic Journal," dated September 1937.

In launching this new publication the Council has announced that it will be published four times each year, and that possibly at some later date it may be published bi-monthly. It will endeavor to supply a "continuing audit of new methods, new products, and new opportunities resulting from scientific research" in its field of "putting chemistry and related sciences to work in industry for the farmer and indirectly for society in general."

Literature Received

A new booklet on "CONCRETE STRUCTURES FOR FLOOD CONTROL AND SOIL AND WATER CONSERVATION" has recently been published by the Portland Cement Association. It is illustrated with photographs of flood and erosion damage and of concrete control works, and with plan drawings of concrete control structures. The Association is attempting to make this booklet available to all interested agricultural engineers, and will welcome requests for copies addressed to it at 33 West Grand Ave., Chicago, Illinois.

the BADGE of him who BELONGS

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The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

DESIGNER familiar with grain, hay, and farm machinery is offered an excellent opportunity by a leading manufacturer of farm equipment. PO-115

DESIGNER, who is an experienced graduate engineer, is wanted by a farm equipment manufacturer for designing agricultural implements. PO-120

POSITIONS WANTED

AGRICULTURAL ENGINEER, 1936 Texas A & M graduate, with one and one-half year's experience in rural electrification, wants employment preferably in rural electric extension work, but will consider openings in other agricultural engineering work. Age 26. Particular experience in southwestern area. PW-285

AGRICULTURAL ENGINEER, farm reared, 1932 graduate of the University of Illinois majoring in farm machinery, four years' experience in ECW and SCS camps in all postions, worked part time while attending the University at agricultural engineering department in maintenance work, desires position with machinery manufacturer in maintenance work, or as a demonstrator. Location immaterial. Married. Age 27. PW-286